S. HRG. 102-60

DEPARTMENT OF ENERGY HIGH-PERFORMANCE COMPUTING ACT OF 1991

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED SECOND CONGRESS

FIRST SESSION

ON

S. 343

TO PROVIDE FOR CONTINUED UNITED STATES LEADERSHIP IN HIGH-PERFORMANCE COMPUTING

APRIL 11, 1991

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DEPARTMENT OF ENERGY HIGH-PERFORMANCE COMPUTING ACT OF 1991

THURSDAY, APRIL 11, 1991

U.S. Senate,
Committee on Energy and Natural Resources,
Washington, DC.

The committee met, pursuant to notice, at 2:03 p.m. in room 317, Dirksen Senate Office Building, Hon. J. Bennett Johnston, chairman, presiding.

OPENING STATEMENT OF HON. J. BENNETT JOHNSTON, U.S. SENATOR FROM LOUISIANA

The Chairman. The hearing will come to order.

We are pleased today to have this hearing on S. 343, the Department of Energy High-Performance Computing Act of 1991. I want to thank Senator Ford for his leadership in this area, and, particularly, Senator Gore for his leadership. Senator Gore has worked many, many years in the area of supercomputers and has helped push this country forward in this area.

While the United States continues to lead the world in the development of high-performance computing, that lead is being challenged. Some estimate that the Japanese will dominate the supercomputer market within the next few years. Yet, the Japanese did not enter the field of high-performance computing until 1983. Today, outside of the United States, Japan is the single biggest market for, and supplier of, supercomputers.

The United States needs an integrated, cooperative effort among industry, universities, and Government in supercomputing to meet the challenge of foreign competition. The purpose of my bill is to establish just such an effort.

The Department of Energy has always had a key role in high-performance computing research. In 1976, when Seymour Cray developed the world's first real supercomputer, it was the Los Alamos National Lab that purchased the new computer for $13 million.

Since that time, the Department's laboratories have become the world's most demanding, sophisticated, and experienced users of supercomputers. Manufacturers of high-performance computers routinely send new prototype computers to the national labs for testing. The labs help the manufacturer identify and solve problems, and write unique software packages. The Department and its laboratories are in a position to help the United States maintain its leadership, strengthen the U.S. computer industry, and encourage the use of supercomputers throughout U.S. industry.

I believe that this bill builds on that proven relationship because it encourages even more collaborations between the national laboratories and other Federal laboratories, universities, and industry.

The bill also calls for the establishment of a national high-speed computer network. This network will link Government, industry, and education. Users across the country will have access to supercomputers, computer databases, and other research facilities.

The bill directs the Secretary of Energy to establish the network. I have selected the Department because I am confident of their capability to run such a network. But perhaps that is not the best approach. I hope the witnesses today will comment on the proper management structure for the network.

I believe the Department of Energy has an important role to play in this issue, and I hope today we can better learn where the Department will make its greatest contribution.

[The prepared statements of Senators Wallop and Domenici and the text of S. 343 follow:]

PREPARED STATEMENT OF HON. MALCOLM WALLOP, U.S. SENATOR FROM WYOMING

Mr. Chairman, I am pleased that the Committee is holding today's hearing on S. 343, the Department of Energy High Performance Computing Act of 1991, of which I am a cosponsor.

High-performance computing and networking is not only essential to our Nation's defense activities, it is also increasingly critical to the competitiveness of our economy and this Nation's economic well being.

Industry is turning to the use of supercomputers for product design, testing and production. I doubt that a decade from now there will be a single product invented or produced—be it a consumer or a military product—without the use of high-performance computers and high-speed networks. The only question in my mind is whether those products will be made here in the United States, or produced abroad.

In the academic and research communities, high-performance computing and networking is likewise increasingly important. There is not a line of scientific inquiry that is either not now using supercomputers, or could not benefit from their use.

Thus, it is important that the Executive branch develop and implement, with the full backing of the Congress through generic authorizing legislation, an appropriate Federal role in the promotion of high-performance computing and networking.

In crafting the necessary legislation, however, it is important that the ongoing process within the Administration not be disrupted. Moreover, it is also important that the authorizing legislation not unduly limit the Administration's flexibility to modify its high-performance computing program as changing circumstances warrant.

I look forward to working with the Administration to craft appropriate and responsible legislation.

PREPARED STATEMENT OF HON. PETE V. DOMENICI, U.S. SENATOR FROM NEW MEXICO

Mr. Chairman, I want to commend you for holding today's hearing.

The legislation before the Committee proposes a major Federal effort to advance high-performance computing and networking. This is of national importance because continued advancement is vital to this Nation's economic growth, to our national security, to our scientific advancement and to our educational efforts.

High performance computing got its start in the late 1940s in the national security field, but today it is ubiquitous. Computers run our telephones; they are used to design automobiles and airplanes; they operate machines on manufacturing lines; they are integral to medical imaging devices; they are used for oil exploration; and they were even involved in the writing of this statement. Computers are now involved in every phase of our everyday life.

Supercomputers are also an integral part of the cutting edge of scientific research. For example, the human genome project would only be a dream without a supercomputer; supercomputers are used to design new drugs to combat illness; and supercomputers will be required to understand the data created by the superconducting supercollider.

If we can expedite the next round of supercomputers and associated software—and transfer that technology to private industry—we can materially benefit our society and economy.

The legislation before the Committee has two key elements. First, it would create a nation-wide, high-speed computer network; and second, it would create supercomputing collaborative consortia to undertake research and development on high-performance computing hardware and associated software.

The proposed high-speed computer network—the "interstate highway system" for computers—would vastly facilitate the transfer of information and promote the efficient utilization of supercomputing resources.

The collaborative consortia would undertake research and development of high-performance computing hardware, software and networks. And given the extensive use of computers in our society, even minor advances will provide major benefits.

I hope that the Administration will work with us to formulate legislation which will compliment and advance the Administration's ongoing high-performance computing effort.

II

102d CONGRESS
1st Session

S. 343

To provide for continued United States leadership in high-performance computing.

IN THE SENATE OF THE UNITED STATES

February 5 (legislative day, January 3), 1991

Mr. Johnston (for himself, Mr. Wallop, Mr. Ford, Mr. Domenici, Mr. Bingaman, and Mr. Craig) introduced the following bill; which was read twice and referred to the Committee on Energy and Natural Resources

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A BILL

To provide for continued United States leadership in high-performance computing.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be referred to as the "Department of Energy High-Performance Computing Act of 1991".

SEC. 2. FINDINGS.

The Congress finds that:

(a) advances in high-performance computer science and technology are vital to the Nation's defense, scientific advancement, international competitiveness and long-term prosperity;

(b) the Department of Energy and other Federal agencies have a critical need for a nationwide high-capacity computer network;

(c) the Department of Energy is the Federal agency having the greatest degree of expertise and knowledge in the research, development and use of high-performance computers, associated software and networks;

(d) the Department of Energy's expertise and knowledge is due in part to its ownership and use of the greatest number of high-performance computers of any Federal agency;

(e) the Department of Energy's expertise and knowledge is also due in part to its numerous national laboratories that have personnel with particular expertise in the research, design, development and use of high-performance computers, associated software and networks; and

(f) the Department of Energy is the Federal agency that is particularly well equipped to undertake additional research and development of high-performance computing hardware and associated software, and to design, implement and manage a multi-gigabit per-second nationwide computer network connecting Federal departments and agencies.

SEC. 3. PURPOSES.

The purposes of this Act are:

(a) to promote the research and development of high-performance computers and associated software; and

(b) to create a multi-gigabit per-second nationwide computer network for use by the Department of Energy and other Federal departments and agencies.

SEC. 4. DEFINITIONS.

For the purposes of this Act, the term—

(a) "Secretary" means the Secretary of Energy;

(b) "Department" means the Department of Energy;

(c) "Federal laboratory" means any laboratory, or any federally-funded research and development center, that is owned or leased or otherwise used by a Federal agency or department and funded by the Federal Government, whether operated by the Government or by a contractor;

(d) "national laboratory" means any Federal laboratory that is owned by the Department of Energy;

(e) "educational institution" means a degree granting institution of at least a Baccalaureate level; and

(f) "software creation" means any innovation or preparation of new computer software of whatever kind or description whether patentable or unpatentable, and whether copyrightable or noncopyrightable.

(g) "Director" means the Director of the Office of Science and Technology Policy.

SEC. 5. DEPARTMENT OF ENERGY HIGH-PERFORMANCE COMPUTING PROGRAM.

(a) The Secretary, acting in accordance with the authority provided by the Federal Nonnuclear Energy Research and Development Act of 1974 (42 U.S.C. 5901 et seq.) shall establish a High-Performance Computing Program (hereinafter referred to as the "HPC Program").

(b) Within one year after the date of the enactment of this Act, the Secretary shall establish a management plan to carry out HPC Program activities. The plan shall—

(1) be developed in conjunction with the Director's overall efforts to promote high-performance computing;

(2) summarize all ongoing high-performance computing activities and resources at the Department that are not classified or otherwise restricted;

(3) describe the levels of funding for each aspect of high-performance computing that are not classified or otherwise restricted;

(4) establish long range goals and priorities for research, development, and application of high-performance computing at the Department, and devise a strategy for achieving them; and

(5) ensure that technology developed pursuant to the HPC Program is transferred to the private sector in accordance with applicable law.

SEC. 6. DEPARTMENT OF ENERGY HIGH-PERFORMANCE COMPUTING PROGRAM ACTIVITIES.

(a)(1) The Secretary shall establish a national multigigabit-per-second computer network to be known as the "Federal High-Performance Computer Network".

(2) The Secretary shall provide for the linkage of the Federal agencies and departments, and other persons as the Secretary may deem appropriate.

(3) The Network shall be designed, implemented and managed by the Secretary of Energy, in consultation with other Federal departments and agencies.

(4) The Secretary may make use of existing Federal facilities and networks as may be appropriate to carry out the requirements of this section, *Provided,* That the Federal department or agency concurs in such use.

(b) The Secretary shall promote education and research in high-performance computational science and related fields that require the application of high-performance computing resources by making the Department's high-performance computing resources more available to undergraduate and graduate students, post-doctoral fellows, and faculty from the Nation's educational institutions.

(c) The Secretary shall establish at least two Collaborative Consortia, and as many more as the Secretary determines are needed to carry out the purposes of this Act, by soliciting and selecting proposals:

(1) Each collaborative consortium shall—

(A) undertake basic research and development of high-performance computing hardware and associated software technology;

(B) undertake research and development of advanced prototype networks;

(C) conduct research directed at scientific and technical problems whose solutions require the application of high-performance computing resources;

(D) promote the testing and uses of new types of high-performance computing and related software and equipment;

(E) serve as a vehicle for computing vendors to test new ideas and technology in a sophisticated computing environment; and

(F) disseminate information to Federal departments and agencies, the private sector, educational institutions, and other potential users on the availability of high-performance computing facilities.

(2) Each Collaborative Consortium shall be comprised of a lead institution, which has responsibility for the direction and performance of the consortium, and participants from industry, Federal laboratories or

agencies, educational institutions, and others, as may be appropriate.

(3) Each lead institution shall be a national laboratory which has the experience in research on problems that require the application of high-performance computing resources.

(4) The consortium may fund research and development associated with prototype computing technology provided that industrial participants in each consortium shall not be reimbursed for costs associated with their own involvement.

(d) The provisions of the National Cooperative Research Act of 1984 (15 U.S.C. 4301–4305) shall apply to research activities taken pursuant to this section.

(e) Each Collaborative Consortium may be established by a Cooperative Research and Development Agreement as provided in section 12 of the Stevenson-Wydler Technology Innovation Act of 1980 (15 U.S.C. 3710a).

(f) The Secretary shall report annually to the Committee on Energy and Natural Resources of the Senate and the Committee on Science, Space, and Technology of the House of Representatives regarding the HPC Program.

SEC. 7. GOVERNMENT AND PRIVATE SECTOR COOPERATION.

In accordance with applicable law, the Secretary may cooperate with, solicit help from, provide funds to, or enter into contracts with private contractors, industry, government, universities, or any other person or entity the Secretary deems necessary in carrying out the provisions of this Act.

SEC. 8. OWNERSHIP OF INVENTIONS AND CREATIONS.

(a) Except as otherwise provided by the National Competitiveness Technology Transfer Act of 1989 (103 Stat. 1674) and any other applicable law, title to any invention or software creation developed under this Act shall vest in the United States and shall be governed by the provisions of section 9 of the Federal Nonnuclear Energy Research and Development Act of 1974 (42 U.S.C. 5908).

(b) Trade secrets and commercial or financial information that is privileged and confidential and which is obtained from a non-Federal party participating in research or other activities under this Act may be withheld in accordance with section 552(b)(4) of title 5, United States Code.

(c) The Secretary, for a period of up to five years after the development of information that results from research and development activities conducted under this title and that would be a trade secret or commercial or financial information that is privileged or confidential, under the meaning of section 552(b)(4) of title 5, United States Code, if the information had been obtained from a non-Federal party, may provide appropriate protection against the dissemination of such information, including exemption from subchapter II of chapter 5 of title 5, United States Code.

SEC. 9. AUTHORIZATION.

There is authorized to be appropriated such sums as are necessary to carry out the purpose of this Act.

○

The CHAIRMAN. Do either of my colleagues have a statement to make?

Senator FORD. I would like to make a short statement if you do not mind, Mr. Chairman.

The CHAIRMAN. Yes, Senator Ford.

STATEMENT OF HON. WENDELL H. FORD, U.S. SENATOR FROM KENTUCKY

Senator FORD. I am pleased to be able to participate in this hearing this afternoon on Senator Johnston's supercomputing bill. This is an issue that is being considered by both the Energy Committee and the Commerce Committee. I sit on both of these committees.

We have a distinguished group of witnesses today, and I am very pleased that they are here. I am delighted to see my good friend and the distinguished Senator from Tennessee, Senator Gore. I know he has worked hard on this issue. He and I sit on the Commerce Committee together, and he has held quite a few hearings there. The Commerce Committee just reported a bill on supercomputing. I know this committee looks forward to working with him and the Commerce Committee on this issue.

Senator Johnston, I commend you for scheduling this hearing before the full committee, because this is an important issue. The supercomputer industry is one of the few technologies where this country still has the lead. That lead, in my opinion and in the opinion of others, is slipping away. We could keep that lead with just a little effort, and I underscore just a little effort, by the Federal Government.

I look forward to hearing from the witnesses this afternoon, Mr. Chairman, on what the Federal effort might and should be.

Thank you, sir.

The CHAIRMAN. Further comments?

STATEMENT OF HON. JEFF BINGAMAN, U.S. SENATOR FROM NEW MEXICO

Senator BINGAMAN. Mr. Chairman, let me just make a very brief statement. I have an opening statement that I will put in the record with your permission. But I do want to compliment you on cosponsoring your bill. I think it is an excellent proposal. I want to compliment Senator Gore, and I cosponsored his legislation on this issue in the last Congress and again this time.

I do think not only is it important that this area of technology be addressed—and it does have a great many ramifications for us throughout our economy and our ability to remain competitive and stay at the lead in science and technology—but also the process that he has identified and that the FCCSET Committee has identified, and yourself, of trying to get the cross-agency coordination of effort I think is very important. It is an example of what we need to do more of in our Government. And I think there is great promise for making progress in this area, and I hope it can be a model for what we can do in some other areas as well.

Thank you.

[The prepared statement of Senator Bingaman follows:]

Prepared Statement of Hon. Jeff Bingaman, U.S. Senator From Mew Mexico

Mr. Chairman, I believe this is an important hearing because it deals with an area of technology that is pervasive and enabling throughout the entire scientific, technological and educational communities. It is clearly one of the critical technologies that appears on the lists compiled by the Department of Defense in their Critical Technology Plan, the Department of Commerce's Emerging Technologies Report, the National Critical Technologies Report, and numerous industrial association reports, such as the Aerospace Industries Association's Key Technologies for the Year 2000.

As you are well aware, I am a co-sponsor of the legislation that is the subject of today's hearing, and I have co-sponsored a related measure S. 272, the "High-Performance Computing Act of 1991," introduced this year by Senator Gore. My co-sponsorship of both measures should provide you with a measure of my interest in this activity. I believe the various facets of the High Performance Computing and Communications initiative, namely the utilization of the Federal Coordinating Council on Science Engineering and Technology (FCCSET) to develop an implementation plan, to integrate and coordinate the overall government effort, presents a model to be used for all critical technologies.

I commend you, Mr. Chairman and Senator Gore for your respective efforts to encourage the Executive Branch to vigorously pursue those technologies that cut across agencies, institutions, and programs.

It is unfortunate that the Department of Energy, until recently, did not view this initiative as a opportunity, but as a potential competitor for the limited set of available funds against those areas of technology that are their traditional constituents, such as fusion, nuclear physics, particle physics, etc.

I believe the DOE must have a strong role to play in this initiative. A role that they have historically played on the area of supercomputers. The Department of Energy has served as the focal point and pioneer in virtually all aspects of supercomputing research and development, from the world's first supercomputer delivered to the Los Alamos National Laboratory to the implementation of cooperative research and development agreements with industry in the area of supercomputing and high-performance communications systems.

As a collective body, the DOE has had more experience with the development of computing, supercomputing and high-performance computing and communication systems than any other scientific body in the world.

I am delighted that Dr. Siegfried Hecker is with us this afternoon and will provide us with testimony as a witness on the final panel. I know Dr. Hecker and the personnel at the Los Alamos National Laboratory have tried to build strong relationships with the private sector to diffuse the technology to a broad segment of our society, to encourage new uses of supercomputers to solve grand-challenge problems, and to assist with the development of software. These are but a few areas where the DOE can be a dominant player in a coordinated, multi-agency effort.

I look forward to hearing Dr. Hecker's testimony as well as the views of our distinguished witnesses on this subject. Thank you.

The Chairman. Thank you, Senator Bingaman.

Senator Craig.

STATEMENT OF HON. LARRY E. CRAIG, U.S. SENATOR FROM IDAHO

Senator Craig. Mr. Chairman, I have no specific opening statement other than to certainly associate myself with the remarks of, I think, the whole committee here, in this instance recognizing the importance of legislation, and I am not going to be specific to S. 343 or to the Gore legislation.

The legislation, I would hope, would recognize the need for the appropriate cooperation and interagency relationship in network consortium development as it relates to this issue. And I would certainly hope that we can ultimately get that job done in crafting legislation with the administration to move the issue. We will be the losers in the long run, and this society will be, if we fail to act and act appropriately.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator Craig.

Senator Gore, we are glad to have you here today.

STATEMENT OF HON. ALBERT GORE, JR., U.S. SENATOR FROM TENNESSEE

Senator GORE. Mr. Chairman, colleagues, thank you so much for your courtesy. I appreciate your participation and leadership on this issue. Mr. Chairman, I am very grateful for this chance to testify on S. 343, the Department of Energy High-Performance Computing Act. I would like to compliment you for your attention to the critical issues in this area.

I would also like to acknowledge the leadership of Senator Ford, who is chairman of the Energy Research Subcommittee and has been deeply involved in these matters and, as he mentioned, has been a key ally in similar efforts in the Commerce Committee, and Senator Bingaman who is the chairman of a subcommittee on armed services that I am privileged to be a member of, that looks at DARPA and related programs in the Defense Department. We have worked together as allies for quite a number of years on these matters, and I especially appreciated your comments a moment ago.

Senator Craig, I am very pleased to have a chance to work with you on this, and I agree with your comments, echoing those of the Chairman, on how important it is to make certain that the interagency relationships are right.

Indeed your opening comments, Mr. Chairman, contain exactly the message that I want to deliver here today. We need to work this out and get it right for the country, and we are coming at it in exactly the right way in a determined effort to cooperate with the administration and between committees. And I am extremely encouraged.

As you mentioned, I have introduced a companion bill to your legislation, S. 272, the High-Performance Computing Act, which would create a multi-agency high-performance computing program, a program which, like the one you have introduced, is, I believe, critical to the future of our country.

Some of what I want to say here you know as well as I do. But let me repeat just a couple of high points. You know, we hear about competitiveness all the time. What makes a difference to a nation's ability to be competitive? It used to be nations with raw materials had an advantage. They still do to some extent. It used to be that nations with deep-water ports or efficient railroad networks or highway systems had an advantage, and they still do to some extent.

But look at some of the countries like Japan that do not have any raw materials, do not have really obvious advantages of the kind that were so prominent when the industrial revolution began. It is obvious today that the key strategic resource is knowledge, information, data. Information configured in a form that can turn it into knowledge would probably be a better way to say it.

Well, we have certainly got enough data. It is all over the place. It is like our old agricultural policy where we used to have the surplus grain stored in silos rotting while people were starving to death. Now we have got surplus data rotting in storage while people are hungry for facts and solutions. Over in the Commerce Committee we oversee the LANDSAT program. You know, it is capable of taking a complete photograph of the earth's surface every 18 days. It has been up there 20 years; 95 percent of those pictures have never been seen by human eyes. They are just stored, waiting.

Now, these high-performance computers can give us the ability to use that information and turn it into knowledge. One of the ways they do it is by presenting it in a form that folks like me can understand. I heard a computer scientist a long time ago describe the human brain as if it were a computer. He said if you look at the way we think you would have to say we have a low bit rate. What that means is that we cannot absorb information bit by bit.

The telephone company decided years ago after much study that seven numbers was the most we can remember. Then they added three. But it is hard for us to absorb numbers bit by bit.

But with pictures, we have high resolution. We can see lots of bits of data in a pattern or in a moving three-dimensional graphic and absorb it just like that. Well, these new advanced computers give us the ability to do that. They also give us the ability to sort through these vast fields of data like the LANDSAT pictures and pick out the mountain peaks or the features that are especially significant for whatever pattern we are trying to put together.

But we cannot use them unless we are in the same building with them because our infrastructure will not accommodate them. We think of infrastructure still in terms of those old railroad lines, and we still need them. But we need an information infrastructure that can make it possible to share the fantastic new ability these advanced machines give us to become competitive in the use of the key strategic resource in the modern world.

That is why we need these information superhighways, and it is why there already is a fledgling program under way that is working pretty well. And if the private sector gets the confidence it needs that we are going follow through on this, then you are going to see preparations in the private sector to add on to this Government backbone network, which will be phased into the private sector anyway as soon as it is viable on those terms.

You know, MCI and IBM and a company called Merit have already formed a nonprofit consortium specially for the purpose of quickly expanding this network so that it can reach all over the country just as soon as they get the clear signal that we are going forward. The Congress can give that signal by passing legislation this year.

Now, we hear a lot, Mr. Chairman, about the word "empowerment." It should not be a partisan word; it is not intended to be. We hear it from Republicans today. I have heard it from Democrats before that. This technology is an empowering technology, an enabling technology. This makes it possible for a school child like Senator Ford's grandson, whom I was with in Kentucky not so long ago——

Senator FORD. You are getting personal, now.

Senator GORE. Yes, that is right.

The CHAIRMAN. Was he your age?

[Laughter.]

Senator **Ford**. Almost.

Senator **Craig**. This is getting personal.

Senator **Gore**. It really is, I will tell you. To make it possible for my son—let me put it that way—or any school child in this country to come home after school and, instead of playing Nintendo, to plug into the Library of Congress, not just to see the text, but to see color pictures of dinosaurs or whatever that child happens to be curious about at the moment; and to get access to exciting information configured and presented in a way that satisfies that curiosity and provokes more and makes it possible for individual children to learn at their own pace, driven by that curiosity.

We know how to do that technically today. Why do we not do it? Well, the reason is, we do not have the infrastructure. A lot of the lines are already there. What we do not have is the switches, the electronics, the software, the algorithms, those tools at either end of the fiber-optic cable that make it possible to upgrade the amount of data that flows through the pipeline.

And you have got to have a lot flowing through the pipeline to send those pictures. That is why we need it. And the supercomputers are so important in their own right. You have had witnesses, as have I over on the Commerce Committee, scientists, who say this is so important. It is now a third new kind of knowledge creation. We have already had inductive reasoning and deductive reasoning; now we have got computational science.

One of my rules of thumb is, if you have got a big list that only has two things on it and you add a third, that is a big deal. And we are doing pretty well on inductive reasoning and deductive reasoning, but we need this infrastructure to prepare our Nation to make use of this third branch of knowledge which is already beginning to revolutionize industry, education, science, and engineering.

As a couple of you all were kind enough to comment, I have been laboring in this vineyard for quite some time. And I will not go through the record on that, but I have learned during that time to greatly appreciate the efforts of those of you I have already singled out, but also Senator Wallop, Senator Domenici, and others who have joined you three in introducing S. 343.

And I agree wholeheartedly with the comments you made, Senator Johnston, about how important it is for DOE to play the critical role it has always played in this area. Due to my many visits to DOE's Oak Ridge National Laboratory and frequent updates from Al Trivelpiece, I am well aware of the leading-edge work being done there and elsewhere, funded by DOE.

Jack Dongarra, Ed Oliver, and others at Oak Ridge are helping to find new and exciting ways to apply the next generation of supercomputers, and reaching out to university researchers in Tennessee and around the country to share and refine ideas. They are working with companies like IBM and Intel and others to improve their newest systems. And I know about the similar work at Los Alamos and Sandia, Livermore, and the other national labs. With passage of S. 343 and additional appropriations these efforts can grow.

Since I first introduced the companion measure, it has often been referred to as "the supercomputer network" bill. That is kind of a misnomer in the sense that less than one-fifth of the funding goes for networking. By far the largest amount goes for development of advanced software for supercomputers so we can make the best use to them.

And it is a misnomer to call it the supercomputer network bill, as well, because the National Research and Education Network will do a lot more than just connect supercomputers, because for every supercomputer there are going to be thousands of PC's and work stations. And we will have what Bill Wulf and others have called a "national collaboratory," a laboratory without walls where people in differing locations can work together on the computer screens.

Now, I mentioned how important it is to stimulate the private sector, and I wanted to underscore that one point with a supplemental point. Because the lines are already there, in most cases, and we develop these switches, as soon as we develop them, they are available to the private sector to use in expanding the network. We have got to figure out how to get that last mile of fiber-optic cable to the home. But the demand generated by the appearance of these new information services will itself stimulate the search for new methods of getting it to the home and will solve that problem.

I have made some specific suggestions there. Some of them are controversial. None of them are directly relevant to what we are talking about here. But what is relevant is that if we proceed with legislation, we will send that signal to the private sector.

Now, the administration sometimes says, well, just give us the money and do not tell us anything about what we should do with the money. You serve on the Appropriations Committee, Mr. Chairman, and you know that that is not unusual for an administration, whether it is Republican or Democratic. They always want Congress to simply give them the money and do not say anything about how to spend it.

But there is good reason for us to say, wait a minute now, we trust you, we think you are on the right track and all that, but we have known OMB occasionally to make some irrational decisions in the following next subsequent budget year. We want to reassure the private sector that we are serious about this, and we are going to follow through on this. And we believe you when you say it was just an oversight that you left education out of your executive branch plan this year. And, in fact, it was an oversight.

But it is an example of the kind of contribution that Congress can make in improving the plan and making sure that it works out well. In fact, their plan came about because we passed legislation. A few years ago you joined me, Mr. Chairman, and Senator Ford did, I know, and I cannot remember everyone who was on it—I believe Senator Bingaman, also—in passing the Supercomputer Network Study Act. That is the reason they had the study.

So this has been a legislative-executive branch partnership from the very beginning. But after they responded to the Senate and the House and got this up and going, they developed some valuable expertise in how to work out these interagency arrangements and to make sure that everybody is moving in the same direction. And it is absolutely imperative, as you said in your opening statement, Mr. Chairman, that we do that correctly.

Over the past few years, the separate agency research networks have been connected together and today comprise INTERNET, a patchwork of hundreds of separate networks that works a lot like the national road system. You have Federally funded superhighways, private toll roads, State highways, local roads, private driveways all connected together. And despite the diversity throughout the system, it works because certain rules apply, like driving on the right-hand side of the road, for example. Whether you are on a city street or an access road leading to a superhighway you are doing that the same way.

And they have developed a flexible approach. I foresee the management of the NREN as being similar to that of the INTERNET or NSFNET. This is the answer to one of the commonly asked questions, who will be in charge? Currently there is a flexible, decentralized approach that enables all the users of the network to have a say. That flexible approach is the principal reason why today the NSFNET is growing at more than 20 percent per month. Every month new networks, public and private, connect to the INTERNET through NSFNET.

S. 272 would continue this approach with coordination, and coordination only, being provided by OSTP. Using the same interagency process that created the High-Performance Computing Program, the agencies would pool their resources and expertise with State, local, and private network providers to build a network far larger and faster than any of them could afford alone.

Of course, each player would be free to run separate networks if that better suited his needs. And each player would be free to design and build his system using different contractors and different equipment, so long as his subnetwork was compatible with other parts of the overall network. Like democracy, such a system would decentralize decision making, putting power in the hands of the network users, and avoiding the dangers of central planning.

Most important, such an approach is flexible enough to adjust as needs and technologies change. When I first got interested in fiberoptic networks in the late 1970's, no one could have predicted how the INTERNET would grow and how it would be used today. For that reason, we need to draft legislation that leaves room for change.

Ideally, we will set broad goals, assign general responsibilities to the participating agencies, provide the necessary appropriations, and then watch this technology take off, watch the private sector make use of it, and elaborate it, and turn it into better versions that we cannot possibly anticipate here today.

I think this is one of the most exciting pieces of legislation before the Congress this year. It has generated excitement in many quarters. Invariably, once people understand what it is about, they are for it. S. 272 has strong support throughout our colleges and universities and in every high-tech sector. Everyone from the American Library Association to the Information Industry Association, to the Chamber of Commerce all are excited by the idea.

So in closing, Mr. Chairman and my colleagues, I very much look forward to working with you on the Energy Committee to pass legislation creating and funding a high-performance computing program. On March 7, I testified over on the House side before Congressman George Brown and the Science Committee which he chairs, and he challenged us over here to pass this legislation within 100 days. He said they are going to beat that deadline in the House of Representatives.

We started this ball rolling over here. I would hate for them to steal the march on us, but they are moving real quickly. I think we can do it. I hope you agree. I really do look forward to working with you closely, and I appreciate the chance to testify today.

Thank you.

[The prepared statement of Senator Gore follows:]

PREPARED STATEMENT OF HON. ALBERT GORE, JR., U.S. SENATOR FROM TENNESSEE

I am very grateful to the Committee for giving me this opportunity to testify on S. 343, the Department of Energy High-Performance Computing Act. As you know, in January, I introduced S. 272, the High-Performance Computing Act, which would create a multi-agency National High-Performance Computing Program. I really believe that this program is essential to the economic well-being of the U.S. in the twentieth-first century, because it will help ensure that the United States maintains its lead in leading-edge computer technology. Without the edge that computer technology can give us, the U.S. will have to stand by as other countries dominate one high-tech industry after another. No matter what sector you look at—aerospace, automobiles, petroleum, the defense industry, pharmaceuticals—computers are making the difference between profit and loss, growth and bankruptcy. That's because computing is an "enabling technology" that contributes to the development and application of all the other "critical technologies" we always hear about—semiconductors, computer-aided design, advanced manufacturing, biotechnology, high-speed communications, and so on.

I first introduced legislation to create a National High-Performance Computing Program in 1988. That legislation would double Federal funding for research and development on advanced computing and create a National Research and Education Network, the NREN, a fiber-optic computer network more than a thousand times faster than the fastest national networks available today. Last year, S. 1067, the High-Performance Computing Act, which included a title from the Energy Committee, passed the Senate unanimously. Unfortunately, the House was unable to act on the legislation before the end of the session.

So in January, I reintroduced the legislation as S. 272. The bill would create a multi-agency program involving the Department of Energy, the National Science Foundation (NSF), NASA, the Defense Advanced Research Projects Agency (DARPA), the National Institute of Standards and Technology (NIST), and several other agencies. By involving all the Federal agencies involved in computing research, the program would build on the strengths that already exist within the agencies and provide for the diversity of approaches which is essential for a successful technology program.

Clearly, a multi-agency program like this will need to be carefully coordinated. That is why S. 272 calls for the White House Office of Science and Technology Policy, which was created by Congress to coordinated multi-agency research, to plan and coordinate this program. As you know, Dr. Allan Bromley, the President's Science Advisor, is also the Director of OSTP. He has provided real leadership in high-performance computing and a wide range of other science and technology issues, in part because he has tapped the talent of some very good people, including your next two witnesses, Dr. Wong and Dr. Nelson. I look forward to continuing to work with Dr. Bromley and OSTP to make this program a reality.

S. 272 authorizes funding for NSF, NASA, and NIST, more than doubling the amount of Federal funding for high-performance computing research at those agencies. In total, it authorizes $1.019 billion over the next five years.

But there is a critical gap. There are no authorizations for DOE's role in the program because it is not the Commerce Committee's job to authorize DOE programs. I am glad that Senators Johnston, Wallop, Ford, Domenici, Bingaman, and Craig have introduced S. 343 to fill that gap. DOE has a critical role to play in high-performance computing.

As science programs become more and more complex, multi-agency programs like the High-Performance Computing Program will become increasingly common. That is going to require much more cooperation and a real effort to ensure that turf fights do not slow things down. I have been impressed by the ability of OSTP to provide the necessary coordination within the Executive Branch, and I am heartened by the increasing cooperation between the relevant committees of jurisdiction here in the Congress. I believe that this initiative can provide a model for cooperation on other areas, like global change, biotechnology, and advanced materials.

I am grateful for the Energy Committee's strong support of the High-Performance Computing Program. I believe the Committee's interest helped convince the Department of Energy that it needs to play a major role in the program. Due to my many visits to DOE's Oak Ridge National Laboratory in eastern Tennessee and frequent updates from Al Trivelpiece, I am well aware of the leading-edge work being funded by DOE. Jack Dongarra, Ed Oliver, and others there are helping to find new, exciting ways to apply the next generation of supercomputers. They are reaching out to university researchers at the University of Tennessee and elsewhere to share and refine their ideas. They are working closely with companies like IBM and Intel to help them improve their newest systems. I know that similar work is being done at Los Alamos, Sandia, Livermore, and the other national labs, and with passage of S. 343 and additional appropriations these efforts can grow.

Since I first introduced high-performance computing legislation, it has often been referred to it as "the supercomputer network" bill. That's a bit of a misnomer, because less than one-fifth of the funding goes for networking. By far the largest percentage of the funding goes for development of advanced software for supercomputers, so that the incredible computing power available in these machines can be put to good use. And it is in this area that the DOE labs have traditionally made their largest contributions. Like NASA, the intelligence agencies, and the National Weather Service, DOE could not accomplish its mission without supercomputers. Every day hundreds of researchers use them to design weapons, develop more energy-efficent technologies, model global climate change, and decipher high-energy physics data. This expertise will be critically important in the High-Performance Computing Program.

It is also a misnomer to call it "the supercomputer network bill" because the National Research and Education Network will do a lot more than just connect supercomputers. For every supercomputer on the network there will be thousands of PCs and workstations. For every person using the network to transmit the billions of bits of data produced by a supercomputer there will be thousands of people using the network to exchange ideas, images, new research results, and requests for information via electronic mail. That will require a network that's both broad and deep, that reaches millions of users and has the capacity to carry billions of bits per second.

One of the most important reasons for building the NREN is that it will spur the private sector to develop and build high-speed computer networks. We all agree that our goal should be to make commercial high-speed networks as ubiquitous and easy-to-use as the telephone network is today. But, that will require tens of billions of dollars to lay optical fiber to every home and to install all the necessary high-speed switches. The Federal government is not going to do that, that is not its job. However, it can spur the private sector by funding the development of the technology needed for such a network, by promoting development of networking standards, and by funding development of applications of high-speed networks.

The NREN will do that. You can think of it as a national demonstration project that will solve the classic chicken-and-the-egg problem we face now. The private sector is hesitant to invest in high-speed networking because they are not sure there is the demand for it. But there is no demand for it because no one has demonstrated the technology. Spurring the development of new technologies, from jet engines to communications satellites, has been a traditional role of government.

In building the NREN it is critical that the private sector be involved from the start. That is why S. 272 would build upon existing computer networks funded by the Federal government, many of which are run entirely or in part by commercial or non-profit companies. Hundreds of thousands of people all around the country rely on networks like NSFNet, NASANet, and ESNet, every day to do their jobs, whether its research, education, or management. By working with the private sector, the funding agencies have spurred creation of several new companies which are hard at work developing new applications for their ever-faster networks.

Over the past few years, the separate agency research networks have been connected so that today together they comprise the Internet, a patchwork of hundreds of separate networks all using the same technology, even though they are controlled and funded by different agencies, States, and corporations. Today's Internet is very much like the national road system; you have Federally-funded superhighways, private toll roads, state highways, local roads, and private driveways, all connected together. Yet, despite this diversity, throughout the system, certain rules—like driving on the right side of the road, apply everywhere.

One of the most commonly asked questions about the NREN is Who will be in charge? The answer is complex, because there will not be one agency or entity in charge. No one person will be able to turn off the system, no more than any one person could shut down the entire national road system. I foresee management of the NREN being very similar to that of the NSFNET or the Internet—a very flexible, decentralized approach that enables all the users of the network to have a say. That flexible approach is why today the NSFNET is growing at more than 20 percent per month! Every month new networks, public and private, connect to the Internet through NSFNet.

S. 272 would continue this approach with coordination being provided by OSTP. Using the same interagency process that created the High-Performance Computing Program, the agencies would pool their resources and expertise with State, local, and private network providers to build a network far larger and faster than any of them could afford alone. Of course, each player would be free to run separate networks if that better suited his needs. And each player would be free to design and build his system using different contractors and different equipment, as long as his subnetwork was compatible with the other parts of the network. Like democracy, such a system would decentralize decision-making, putting power in the hands of the network users, and avoiding the dangers of central planning.

Most importantly, such an approach is flexible enough to adjust as needs and technology change. When I first got interested in fiber optic network in the late 1970's, no one could have predicted how the Internet would grow and how it would be used today. For that reason we need to draft legislation that leaves room for change. Ideally, we will set broad goals, assign general responsibilities to the participating agencies, provide the necessary appropriations, and then watch this technology take off.

I think this is one of the most exciting pieces of legislation before the Congress this year. It has generated excitement in many quarters. Invariably, once people understand what it is about, they are for it. S. 272 has strong support throughout our colleges and universities and in every high-tech sector. Everyone from the American Library Association to the Information Industry Association to the Chamber of Commerce are excited by the idea.

I look forward to working with my colleagues on the Energy Committee to pass legislation creating and funding a High-Performance Computing Program. On March 7, when I testified before Congressman George Brown and the Science Committee which he chairs, he challenged me to pass this legislation within 100 days. I think we can do it, and I hope you agree. This bill is too important to delay.

The **Chairman**. Senator Gore, thank you very much for an excellent statement. You very well state the case for a national computer network. I hope that in the process of getting it we can—the really thrilling thing would be to get the whole country, including private homes, tied together with fiberoptic cable, which has implications even beyond computers; I mean, for television, for information, for everything. And they tell me that a little push from the Government might get private people to want to do that.

The head of one of our big corporations who might be interested in doing that said just that.

Senator **Gore**. I agree.

The **Chairman**. Little more than a resolution of intent by the Government would, I think, push some of the private sector people into wanting to do that, and this may be the way to do it, not that the guiding force behind this bill is anything other than computers, but it is a very important piece of lagniappe for this bill. Lagniappe, to those of you who are not from Louisiana, means a little extra portion, a little extra goodie.

In any event, we do look forward to working with you. You have given us leadership in this area for a long time, and we hope we can work something out that we can both support. I expect that we can. We came very close to it last year. As you know, it was in the waning hours of election year.

Senator GORE. We were this close, Mr. Chairman.

The CHAIRMAN. But I think we can do it this year, and we will certainly try to do that.

Senator GORE. Great.

The CHAIRMAN. We appreciate it very much.

Senator Ford, did you have some questions.

Senator FORD. I have no questions.

The CHAIRMAN. Senator Craig.

Senator CRAIG. Senator Gore, let me thank you for your statement and, obviously, your leadership and your enthusiasm in this area. It is an area that I have watched somewhat from afar, recognizing its value, but having other priorities, knowing that you and Senator Johnston and others were pushing aggressively in this area.

You had mentioned in your comments—and I wanted to search that out a bit and underline it. Would you not agree that it would be a mistake to pass legislation that might be overly prescriptive in this area?

Senator GORE. Yes. These terms need to be defined, but yes, I agree not only with your language, but with what I take to be the thrust of your statement. I do believe that we need to say what this is designed to be and to send a clear signal with multiyear authorization long enough, 5 years, to complete the network, to tell the private sector, look, we are serious about this, we are doing this.

Senator CRAIG. I ask you that question with no intent of boxing you in at all, other than we have had some expression from the administration concerned about either your legislation or ours becoming, if you will, too prescriptive, offering the direction, offering the guidance and the thrust, but at the same time not restricting or providing limitation by the parameters we set.

Senator GORE. I agree with that totally. And I would like to compliment Allen Bromley on his outstanding leadership on this question. The differences are so minor, really, as to not be worth mentioning except that we need to assert the role of the legislative branch of Government. And we did start this and get it rolling, and we need to recognize that it will turn out better if we do continue that role. But I agree with you.

And they have—partly because of Dr. Bromley, they have worked out already in the executive branch a mechanism for cooperation that facilitates a growth rate which I cited before—let me repeat it—of 20 percent per month. That is pretty phenomenal. And we need to respect what they have done. That is why the legislation is carefully crafted to conform with the work that is already under way.

Senator CRAIG. Thank you. Thank you, Mr. Chairman.

Senator FORD. Mr. Chairman—no, I will wait for Senator Bingaman. I have just got a point I want to make.

Senator BINGAMAN. Why do you not go ahead.

Senator FORD. Let me see if I understand the positions that we have got in here. Senator Gore's bill would have NSF manage the network, as I understand it, and Senator Johnston's bill would have the Department of Energy manage the network. Then, in reading Dr. Wong's testimony and Dr. Nelson's, they say that the administration already has worked out a management structure. Am I correct in that back there, that the administration would prefer that we leave it at that?

It seems to me there is an obvious middle ground, and I want to throw that out here right now while Senator Gore is here. Perhaps the thing to do is to pass a piece of legislation that simply directs the President to establish the network. We could leave the President the discretion to decide maybe the appropriate agency and their roles. And I think it may be wise not to be overly restrictive, or prescriptive—I do not know whether that—I am not sure I know all the language here—but it should not be too restrictive.

The important thing to me in my book is to establish the network and get it operating, Al.

Senator GORE. That is right.

Senator FORD. This may be a solution that will make everyone happy, I do not know, or make everybody mad.

Senator GORE. Can I respond to that?

Senator FORD. You sure may, because we will not have to fight, if we can work out who is in charge, and the administration will have the flexibility to get it done. That is what I think you want.

Senator GORE. That is exactly right. And all three of us, the Energy Committee, the Commerce Committee, and the administration—and, I might say, the Armed Services Committee, because the Armed Services Committee has authorized a chunk of this also. All of us are singing from the same sheet of music. Now, there may be, you know, a base line and a tenor line, or whatever you want to use for the metaphor, but we are heading in exactly the same direction.

I would use a slightly different description of what you had earlier, because the key to what we need to work out is to be found in your statement that we are trying to get NSF to manage it. What we want is exactly what they have now in those terms. NSF is the lead agency for facilitating the coordination of the management by the users. That is why it is working so well now.

Let me read to you from the S. 272 report language. It says, "NSF would be lead agency responsible for coordinating the efforts of agencies involved in deploying the network. As such, it will be responsible for building consensus among the agencies on network standards and policies in accord with the general policy guidance provided by FCCSET." That is exactly what they are doing now.

Senator FORD. Well, Al, that gives them discretion to do it, and if we put in into statute, or make it statutory, then I am concerned that the next administration would want to change it. And then we get back into—if they are doing what they are doing now and that is correct, I would hate—I mean, they obviously are doing it right without being told, in your opinion.

And so I would—I would hate to have the administration locked in. I would like to have some "generic" language. I am trying to get this thing on track, and I can see some bumps that we do not need. And if we could agree on this situation, we might be able to move something out of here very quickly.

Senator GORE. This is the one speed bump, if you will, that has slowed it down, and I agree with you. This can be worked out. We should not underestimate the amount of time and attention to detail, and willingness to have a shared give-and-take on this necessary to resolve this point. But, Senator Ford, just letting the administration do it by executive fiat with us simply appropriating the money and say, you spend it however you want——

Senator FORD. You have oversight, though, Al.

Senator GORE. Well, I understand that. But the key point is this: the private sector is out there waiting, ready to go as soon as they get a clear signal. The multiyear authorization is the clear signal. Now again, on this one point, the speed bump, if you will, what I read is the report language. The actual language says NSF shall act as lead agency in coordinating the collaboration.

Senator FORD. But we are telling them what to do, and that usually gets the hair up on the back of their neck.

Senator GORE. Well, I am confident we can work it out. I really am——

Senator FORD. I just think we have an opportunity of putting it into place and saying do it, and then we can follow up with oversight. And then if it is not being done, we can always have an opportunity—I would rather add something to it at a later date than try to take something away from it.

The CHAIRMAN. Senator Gore, I know you are going to probably have to go someplace later. I am sorry, because I wish you could be here for the administration. I understand they are going to testify that they want to do just what you want to do. They want to get it accomplished, and I do not think they would object to multiyear authorization. I do not think they would object to the mandate. I think they object to us telling them how to do it either in DOE or NSF.

Senator FORD. I think that is what I am trying to say here, and it looks like we have got it going in the right direction and we can move on with it. I think you are on board as far as you can be.

The CHAIRMAN. I think so. I mean, we would like it in DOE; you would like it in NSF. The administration does not mind doing it. Maybe we can meet together on some kind of generic authority with a multiyear authorization and tell them to get——

Senator FORD. If we can get the generic language and multiyear authority, let us just settle this thing and you all will not have to testify and we can go to lunch.

Senator GORE. I will just say one other thing, Mr. Chairman. We do not—when you say you want it in DOE, we want it in NSF, what we——

The CHAIRMAN. Well, coordinating or whatever you want to call it.

Senator GORE. We want the NSF to have the responsibility that it has now, and DOE to have the responsibility and participation it has now. That is what we are asking for.

The CHAIRMAN. Well, they do not have statutory authority. You want to seal into the statute that which they are doing now and then expand what they are doing.

Senator GORE. Well, rather than draw a line in the sand and fence over the wording of it, let me say, Mr. Chairman, that I am very encouraged that we really do want the same thing, which is to see the network in place. We all agree that the administration is doing a good job on it. If we and the private sector had total confidence that they would win their battle with OMB next year the way they did this year and 5 years from now the way they did this year, then everything would be hunky-dory.

Since we do not agree with the administration on that, you all seem to share my point of view that we should have a multiyear authorization. The sole remaining difference among us is, what in that multiyear authorization should be said which authorizes the program but does not upset the administration's ability to use the arrangement it now has. Let me conclude by saying, I have an open mind, I want to work with you on it, we have the same objectives, and I stand ready and eager to work out the tiny differences that remain.

The CHAIRMAN. Well, I appreciate that very much. It sounds like to me that we are coming toward a closure here, because—I mean, I think we can accomplish what we want as the first objective, and that is to get the mandate and the multiyear, to not upset the present arrangement, and not to seal it in the law either. It exists because that is what the Federal Government has chosen to do, and I expect that they will continue to do that. But they very strongly, as I think they are getting ready to testify, want to keep the discretion to do that and to have that flexibility as time goes on.

Senator GORE. Mr. Chairman, since I cannot stay, let me just leave you with an inoculation against their seductive testimony——

[Laughter.]

Senator GORE [continuing]. In the form of a brief reminder, which is perhaps completely unnecessary, that administrations dating back to George Washington's time have always approached the Congress with the eager request that all the money be given with no instructions on how to spend it. And I know that this Committee, among all in the Senate, is capable of resisting that siren song.

The CHAIRMAN. Senator Bingaman I think still has some questions.

Senator BINGAMAN. This has been enough. I will wait for the next ones.

The CHAIRMAN. If you want instructions, S. 343—is that our number? We give some good instructions there. If you can sign on with those instructions we will be happy.

Thank you very much, Senator Gore. We will work this thing out.

Senator GORE. Thank you.

Senator FORD. Mr. Chairman, I do not know whether Senator Craig remembers or not, or is familiar, but about 12 or 14 years ago your colleague, Senator McClure had a piece of legislation that struck me as being a rather good one, and that was to abolish OMB.

Senator GORE. I will second the motion.

Senator FORD. I want you to know it might be time to bring that back up.

Senator **Craig**. Mr. Chairman, I think Senator Ford, if he would choose to author such legislation today, would find a flurry of cosponsors, including myself.

The **Chairman**. With that we will call on our first panel, which is Dr. Eugene Wong, Associate Director of Physical Sciences and Engineering in the Office of Science and Technology, the Executive Office of the President, and Dr. David B. Nelson, Executive Director of the Office of Energy Research of the Department of Energy.

Gentlemen, your written statements will be put into the record. I wish you would summarize in about 5 minutes each, and let us see if we can get to the core of this problem with little discussion here.

STATEMENT OF DR. EUGENE WONG, ASSOCIATE DIRECTOR, PHYSICAL SCIENCES AND ENGINEERING, OFFICE OF SCIENCE AND TECHNOLOGY, EXECUTIVE OFFICE OF THE PRESIDENT

Dr. **Wong**. Thank you, Mr. Chairman, Members of the Committee. I am delighted to be here and I appreciate the opportunity to offer my comments on S. 343.

As you know, on February 4th the President proposed his fiscal year——

Senator **Ford**. Dr. Wong, I apologize to you. Would you pull the microphone a little bit closer?

Dr. **Wong**. Yes. On February 4th President Bush proposed his budget for fiscal year 1992. Among the major research and development projects is the high-performance computing and communications initiative. The initiative is the result of several years of interagency cooperative effort conducted under the auspices of FCCSET, the Federal Coordinating Council for Science, Engineering, and Technology.

It really represents a carefully reached balance of common goals and individual needs. And it really represents a degree of mutual trust and synergy that is rare in or out of Government. It has been my privilege to be associated with the tail end of this process. The origin of the initiative, as you know, was in the long-felt need for a Federal role in fostering the development of supercomputers.

As the process evolved, as the consideration for an appropriate Federal role was developed, the program has evolved into something much more than merely a supercomputer program. It represents most major frontier areas of the computer technology. It has four major parts: high-performance computer systems, applications and algorithms, high-speed networking, and basic research and human resources. In each of these areas there are major, exciting goals that have been set.

For example, in computer systems we hope to develop, within 5 years, computer systems capable of a trillion operations per second. If realized, that will represent a thousandfold increase in speed from what is available now. In networking, you have already heard from Senator Gore. We have ambitious plans. The current speed of the NREN, the network, is already a thousandfold increase from what it was 5 years ago and we hope, under this program, to reach yet another hundredfold increase in speed.

The **Chairman**. In what period of time?

Dr. WONG. In 4 to 5 years, to gigabit rate. As exciting as these technology goals are, they are merely technology goals. But the real vision of the program is far more than merely technology. The vision is not only technology development, but also timely deployment of the technology to foster major economic development, to impact the mainstream of the entire information technology industry, and wide diffusion of the benefits to all sectors of our society.

And specifically, I think the objective of the initiative is threefold. First, to stimulate the growth of the computer and information technology industry through the Federal support of precompetitive, leading-edge technology. Second, to deploy the advances so obtained to serve major areas of national needs. These include education, national security, health care, and the environment. And thirdly, to strengthen the scientific infrastructure of the Nation through the support of human resources and basic research, through the support of computational sciences such as computational aerodynamics, computational biology and, last but not least, through the development of a major research and education network.

In each of these areas, the need for a Federal role is both clear, justified, and compelling; however, the Federal role is at best a catalytic one. For the program to succeed in attaining and achieving its overall vision, private industry has to be catalyzed into early action. Private investments have to be stimulated by the Federal support of leading-edge technology. I think this point cannot be over-emphasized. The vision is not merely one of technology development, but the vision really is through technology development to catalyze the entire private sector into coordinated action.

I believe the initiative has broad-based support. Someone told me last week, someone from the private sector said last week everyone disagrees with the details of your program here and there, but there is no one who would disagree that there should be such a program.

And I think that is true. There is indeed broad-based support. The endorsement and guidance of Congress is very much needed here. However, legislative proposals pending before Congress point out certain risks in mandating such a program by law.

First, there is the risk of prematurely freezing the program when technology changes require that the program remain flexible.

Second, there is a danger in micromanaging the program through over specifying the details. And thirdly, any deviations from the carefully crafted balanced program that has been reached has a danger of destroying the synergy and mutual trust that has been developed over the last few years among the agencies.

I think S. 343 is relatively free of such features, although it is not entirely free of such features. For example, I think S. 343 recognizes only contributions of the Department of Energy.

It assigns the primary role, the principal role for the establishment and management of gigabit network through the Department of Energy and it mandates the establishment of collaborative consortia by DOE which is an implementation detail that DOE has existing authority to undertake and is very likely to undertake.

In closing, I would like to say that, Mr. Chairman and Members of the committee, that we share your interest, enthusiasm and high hopes for the High-Performance Computing and Communications initiative. And I am confident that we can reach a consensus on how best to attain its goals.

I would like to thank you again for your courtesy and for allowing me to testify here today.

[The prepared statement of Dr. Wong follows:]

Prepared Statement of Dr. Eugene Wong, Associate Director, Physical Sciences and Engineering, Office of Science and Technology Policy, Executive Office of the President

Mr. Chairman and members of the Committee: Thank you for giving me the opportunity to testify on the critically important issue of high performance computing and communications.

On February 4, 1991, the President announced his proposed budget for Fiscal Year 1992. Among the major new R&D programs in the budget is a Presidential initiative on high performance computing and communications, which is described in the report Grand Challenges: High Performance Computing and Communications. The report, which was released on February 5, 1991, was produced by a Working Group on High Performance Computing and Communications under the Committee on Physical, Mathematical, and Engineering Sciences, which is one of seven umbrella interagency committees under the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). A copy of the report is attached.[*]

The overall goals of the high performance computing and communications initiative are symbolized by a set of what are called "grand challenges," problems of important scientific and social value whose solution could be advanced by applying high performance computing techniques and resources. These grand challenges include global climate modeling, mapping the human genome, understanding the nature of new materials, serving national security needs, and the design of ever more sophisticated computers. Many such problems, including ones unforeseeable today, can be addressed through high performance computing and communications.

The initiative represents a full integration and coordination of component programs across a number of Federal agencies, building upon those programs where appropriate. The initiative proposes to increase funding in these programs by 30 percent, from the 9 million appropriated in FY 1991 to $638 millions in FY 1992.

HISTORY OF THE INITIATIVE

The HPCC initiative can trace its formative years to the early 1980s, when the scientific community and federal agencies recognized the need for advanced computing in a wide range of scientific disciplines. The Lax Report of 1982 addressed the need for supercomputer centers beyond those at DOE's national laboratories. As a result, the availability of such resources to the basic research community expanded—for example, through the establishment of supercomputer centers by NSF and NASA.

In 1982 a FCCSET committee examined the status of supercomputing in the United States and the role of the federal government in the development of this technology. In 1985 this committee recommended government action necessary to retain America's technological supremacy in this area. OSTP synthesized subsequent planning, studies, and reports in its 1989 report, The Federal High Performance Computing Program.

The initiative in the FY 1992 budget represents an implementation of the 1989 plan, appropriately updated to recognize accomplishments made to date. The 1989 report described a five-year program to be undertaken by four agencies—the Defense Advanced Research Projects Agency, the National Science Foundation, the Department of Energy, and the National Aeronautics and Space Administration. The program has since been strengthened by the addition of four more partners—the National Library of Medicine within the National Institutes of Health, the Environmental Protection Agency, and the National Institute of Standards and Technology and National Oceanic and Atmospheric Administration within the Department of Commerce.

The planning and implementation of the HPCC program resulted from extraordinarily effective collaboration by the participating agencies using the FCCSET forum. This program required several years of discussions and hundreds of hours of negotiations and interactions among all federal agencies interested in computing. Agencies have realigned and enhanced their HPCC programs, coordinated their activities with other agencies, and shared common resources. The final product represents a complex balance of agency relationships and agreements forged over a number of years.

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[*] The report has been retained in committee files.

These agencies have achieved a level of mutual trust, cooperation, and synergism that is remarkable in or out of government—and not easily achieved. In addition, the success of this effort demonstrates the advantages to be gained by using the FCCSET process to coordinate areas of science and technology that cut across the missions of several federal agencies. The FCCSET process maintains the flexibility and balance necessary for a truly integrated science and technology program to evolve, and it allows additional agencies to identity opportunities and participate as well.

DESCRIPTION OF THE INITIATIVE

The HPCC initiative is a program for research and development in leading-edge areas of computing. The program has four major components: (1) High Performance Computing Systems, (2) Advanced Software Technology and Algorithms, (3) a National Research and Education Network (NREN), and (4) Basic Research and Human Resources. The program seeks a proper balance among the generic goals of technology development, technology dissemination and application, and improvements in U.S. productivity and industrial competitiveness. It incorporates general purpose advanced computing as well as the challenges ahead in massively parallel computing.

In the development of computing hardware, ambitious goals have been set. The program seeks a thousandfold improvement in useful computing capability (to a trillion operations per second). The focus will be on the generic technologies that will prove valuable in many different sectors. Where appropriate, projects will be performed on a cost-shared basis with industry.

In software development, the program will focus on the advanced software and algorithms that in many applications have become the determining factor for exploiting high performance computing and communications. In particular, software must become much more user-friendly if we are to provide a much larger fraction of the population with access to high performance computing.

The National Research and Education Network (NREN) would dramatically expand and enhance the capabilities of the existing interconnected computer networks called the Internet. The overall goal is to achieve a hundredfold increase in communications speed (to levels of gigabits per second). In addition, the number of "on-ramps" and "off-ramps" to the network would be greatly expanded, bringing the potential of high performance computing to homes, offices, classrooms, and factories. Such a network could have the kind of catalytic effect on our society, companies, and universities that the telephone system has had during the twentieth century. A new meaning will be given to communication, involving not just the transfer of knowledge but a full sharing of resources and capabilities that no single site possesses. The NREN also has the potential to become an important component in meeting our National Education Goals in science and mathematics achievement by the year 2000.

Finally, the HPCC initiative will add significantly to the nation's science and technology infrastructure through its impacts on education and basic research. The successful implementation of this program will likely lay the foundation for changes in education at all levels, including the precollege level.

Execution of the HPCC initiative will rely heavily on the synergy that has been carefully cultivated among the participating agencies. This synergy has been fostered by allowing each agency to do what it does best in the way that it does best. DOE, for example, through its national laboratories, has always led in the development, use, and application of HPCC technologies to cutting-edge scientific problems. DARPA will lead in fostering the development of breakthrough system technologies, as it has done in the past for time-sharing, network operating systems, and RISC architecture. NASA will continue to pursue a new wave of space-related and aeronautics problems, as well the collection, modeling, simulating, and archiving of space-based environmental data. And NSF's close ties with the academic community give it special expertise in education and coordination and use of NREN.

EXPECTED RETURNS OF THE INITIATIVE

The high performance computing and communications initiative represents a major strategic investment for the nation with both economic and social returns.

Few technology initiatives are likely to have the same potential to impact the ways we live and work than does the high performance computing and communications initiative.

The high-performance end of the computer market is relatively small, but its influence far transcends its size. The high end is where leading-edge technologies and applications are developed. Recent history indicates that these developments diffuse so quickly throughout the overall market that "superminis" and "superworkstations" are no longer contradictions in terms. A federal investment in the leading-edge computing technology will speed the growth of the overall computer market and may catalyze investments on the part of U.S. industry. At the same time, supercomputers are not the only important hardware component; we shall not forget the importance of the smaller, more widely distributed units and their role in the overall system.

The HPCC initiative will also make major contributions to national needs. Energy, national security, health, education, and environment are only some of the concerns that depend on high performance computing and communications. This dependence will grow as computers become more powerful, cheaper, and more usable.

HPCC is also critical for the nation's scientific infrastructure. The electronic computer was born as a scientific tool, and its early development was driven by scientific needs. Business applications soon came to dominate its development, but recently there has been a renewed focus on computers as an instrument in science. Indeed, "computational science," which incorporates modeling, simulation and data rendition, is adding a third dimension to experimentation and theory as modes of scientific investigation. In field alter field of fundamental and applied sciences, problems intractable for either theory or experimentation are being successfully attacked with the aid of high speed computation.

DIFFUSION OF THE INITIATIVE'S BENEFITS

If the HPCC initiative is to realize its full potential, it is not enough that it reach its technology goals. It is equally important that the technologies be deployed by the private sector in a timely way to accelerate market growth. It is likewise insufficient for applications to be developed and problems to be solved; the benefits accruing from those solutions must be disseminated in order to influence our everyday lives.

The continued development and use of government-funded HPCC prototypes can significantly impact the potential commercialization of these technologies. Furthermore, many organizations that cannot individually justify the hardware investments will be able to gain access to these new computing systems via the new network. Thus, the knowledge gained through the timely development and use of prototype systems and the access provided to them by the network will significantly improve the dissemination of the benefits of the initiative.

This wide diffusion will not be possible by federal action alone. The Administration's HPCC initiative will be most effective as a catalyst for private actions. Some analysts have suggested that the HPCC initiative can spur several hundred billion dollars of GNP growth. If so, it will be because American companies, both large and small, are able to deploy the technologies in producing quality goods and services. Similarly, if the NREN is to lead to the establishment of a truly national high speed network, as many predict, it will be because private investments are stimulated by government leadership. Far from suppressing or displacing free market forces, the HPCC initiative will strengthen them by providing the impetus for vigorous private action.

CONGRESSIONAL INITIATIVES IN HIGH PERFORMANCE COMPUTING AND COMMUNICATIONS

The breadth and balance of the high performance computing and communications initiative are critical to its success. Maintaining this balance among program components and across agencies is the most important priority in the program. For example, powerful computers without adequate software, networking, and capable people would not result in successful applications. Similarly, a program that created only high performance networks would not satisfy the need for greater computing performance to take advantage of the networks and solve important problems.

The Administration's initiative also relies on substantial participation by industry and government laboratories to overcome barriers to technology transfer. Cooperative government, industry, and university activities will yield the maximum benefits derived from moving new technologies from basic discoveries to the marketplace.

The legislative proposals pending before the Congress, though well intended, do not fully recognize the comprehensive interagency effort brought about through years of collaboration. For example, S. 343 recognizes the contribution of only the Department of Energy, one of the eight agencies currently participating in the HPCC initiative. Furthermore, S. 343 assigns to the Department sole responsibility for the establishment and management of a multigigabit-per-second network. S. 343 also mandates the method establishment of collaborative consortia—in which that responsibility should be executed. Although the Department is a major player in the Administration's own plans regarding the NREN, other agencies, including the DARPA, NASA, and NSF, also have critical roles to play. This legislation, like others now before Congress, may detract from existing efforts by causing an unintended revision of complex relationships forged between the agencies.

Legislation should not limit the flexibility of what is by nature an extremely dynamic process. In particular, legislation should not attempt to micromanage the Administration's current plan nor the delegation of responsibility to FCCSET or the agencies. In addition, legislation should not seek to codify research plans into law—this suggests that research is static, when in fact the pace of technological change, particularly for HPCC, is so dramatic. Research plans for interagency programs are inevitably dynamic, just as the research efforts they describe are dynamic and evolving.

One example of the fast-paced nature of this research is a joint Los Alamos National Laboratory/DARPA effort that successfully applied an innovative massively parallel Connection Machine Computer system to a nuclear weapons safety code to gain new and valuable insights into the safety of the nuclear weapons inventory. Significant achievements have also been made on the networking front. The speed of NSFNET, for example, has increased a thousandfold (from 56 kilobits per second to 45 megabits per second) since 1988.

It bears emphasis that the Administration's initiative uses the existing statutory, programmatic, budgetary, and authorizing authorities of the agencies and departments involved in the initiative, including OSTP. The funding levels necessary to proceed with this effort have been transmitted to the Congress in the President's request and are clearly reflected in the budgets of each of the eight agencies involved in the initiative. The Congress already has the ability to affect positively the high performance computing program of the federal government through existing authorizations and appropriations. Positive action on the requested appropriations will ensure that this extensive interagency program can go forward.

Mr. Chairmen and members of the Committee, we in OSTP appreciate Congress' interest in the high performance computing and communications initiative. We share the same goals, and I am confident that we can reach a consensus on how best to achieve them. Thank you again for the opportunity to testify.

The CHAIRMAN. Thank you very much, Dr. Wong.

Dr. Nelson.

STATEMENT OF DR. DAVID B. NELSON, EXECUTIVE DIRECTOR, OFFICE OF ENERGY RESEARCH, DEPARTMENT OF ENERGY

Dr. NELSON. Thank you, Mr. Chairman and Members of the committee.

I have submitted my written testimony also, so I will confine my oral testimony to a few remarks. In particular, I will make three general remarks, plus then some specific comments on S. 343.

I agree entirely with the comments, the testimony that Dr. Wong has given, and he has given an overview of the administration's program, so I will dip down into a few specifics.

My first remark is that on behalf of the Department of Energy, I certainly welcome the congressional interest in the High-Performance Computing and Communication initiative, and I agree with Senator Gore's testimony that the congressional interest has been helpful to us in arriving at the position we now are at.

The Congress has certainly added value to the programs and proposals of individual agencies in the administration. It has been a fruitful partnership so far.

We welcome the interest because we believe the program is important to the country and the Department, and from your opening remarks, it is clear that the Congress believes so also.

But I would have to say, in agreement with Dr. Wong, that it is difficult at this point to frame legislation that does not run the risk of being overly precise and perhaps not standing the test of time, even 5 years, in a rapidly moving technology program.

As Dr. Bromley has testified, we would prefer that the Congress not brick us in, and I am the chairman of the working group that is responsible for coordinating the High-Performance Computing and Communication initiative under FCCSET.

It has been difficult but productive for me as an individual, and for our agencies together, to arrive at the consensus that we are in. There have been many times that we have changed direction slightly as we have learned more.

In some cases, we have reassigned roles, as we have learned more about how to accomplish goals. I am worried that legislation that is premature and overly specific might cause this consensus to break apart and the productivity of the program to fail.

I would remark that we have been very careful in forming the initiative, to make our goals and our objectives in terms of outputs. Congress knows or can know what we intend to accomplish and we can stand accountable for what we intend to accomplish.

As Dr. Wong has testified, salient goals of the program are to increase the capability of our computing systems on real applications by one—thousandfold by 1996, and to increase the capability of our communication networks by hundredfold by the same time frame. These are very specific goals, and ones by which we can be measured.

Let me go to my second remark. With some pride, I think the agencies have begun already to implement the goals of the High-Performance Computing and Communications initiative. Although the program does not start formally with Congress agreement until the fiscal year 1992, the Department of Energy and several other agencies have undertaken things to get ready for this.

Let me speak of some of the activities that the Department of Energy has undertaken. First, we have installed in our national laboratories several advanced architecture experimental computers and we have ported or moved applications over to these computers to see what these advanced architectures can do.

We have had good success. We have been able to achieve speed records on some codes, and we have learned the characteristics of codes that suit them for certain architectures.

Based on this, I am confident that the goal of the program, that we can achieve computers with 1 trillion operations per second on realistic applications by 1996 is credible and feasible, and this is an accomplishment already: the building of the confidence that that goal is feasible.

In another area, we are about to announce the early start of several grand challenge collaborations at our national laboratories. Several of these will have industrial, significant industrial participation, and starting in 1991, they will give us feedback that will help us learn how to structure future collaborations so as to achieve initiative goals.

In the networking area, our Energy Science Network, ESNET, is now based on network standards, industrial standards and is interconnected with the other agency networks and with regional networks, to be a part of the INTERNET and then a basis for the future National Research and Education Network.

We are also sharing with other agencies in research that is needed if we are to develop NREN as a one gigabit network, and we are also jointly procuring international links with other agencies, saving money, compared with going our separate ways.

In another area of the initiative we will shortly announce the first recipients of DOE Computational Science Fellowships. We have had 400 some applicants, and the 22 about to be announced are really superlative students, showing that the area of computational science is one that students want to get into. They are eager to start.

We have also expanded our successful high school student and teacher training program, using the supercomputer at our National Energy Research Super Computer Center that was donated by Cray Research, Incorporated. This computer is for the exclusive use of high school science and mathematics educational programs around the country.

These are some examples, but by no means the only ones of our early start to be ready for the 1992 program.

Let me turn to my third remark. DOE participates eagerly with the other agencies in the High-Performance Computing program and in specific, with the National Research and Education Network component of it.

But we have specific requirements because of our role as a mission agency, and especially in the networking area. We have certain requirements that we believe must be fulfilled if we are to continue to be able to do our mission in the computing and communications arena.

These include, first, we need to have assured and reliable network links between our researchers and the resources that they need to access: computers, experiments and databases.

Any common usage of links that could lead to saturation and restriction of throughput would have serious effects on our programs. Historically, this has happened on occasion and is something that we would need to avoid in developing the NREN.

Also, we must retain mechanisms to involve our users in monitoring network operations because in the last analysis, the network is serving their work in achieving our missions. Currently, we do this through the ESNET steering committee and believe that user involvement needs to be maintained through the NREN as well.

Next, because money will be constrained for the NREN, we believe that the NREN must be requirements-driven. The lines have to be put where the usage and the users are. It cannot simply be a technology demonstration. It must be a functional network meeting requirements for usage.

And finally, we believe that the Department of Energy and the Federal Government will continue to require its own presence in networking research and in very high-end network deployment.

Historically, the commercial networking interest has not extended to the very leading edge where Federal missions require networking, a very high-band width, specialized services, specialized forms of interconnect.

We believe, and are working earnestly to achieve the commercialization of aspects of the NREN in a technology transfer and function shedding mode, but we at present do not believe it would be possible simply to commercialize the NREN lock, stock and barrel and remove the Federal presence from very high-end network research and deployment.

Those are my three general remarks. Now let me turn to S. 343 and I will offer three comments on the bill. First, S. 343 assigns the responsibility for High-Performance Computing and Communications management to the Secretary of Energy, and while we are flattered by your confidence, we believe that existing interagency management structure is appropriate without modification. It is working now on a consensus basis, and we think that is the best way.

Second comment on S. 343 is that it calls for the Secretary to establish at least two collaborative consortia to be led by national laboratories. Such consortia are already within the scope of the administration's High-Performance Computing and Communication program, and they are consistent with the National Energy Strategy.

And as I mentioned, our early start program this year already or soon will, as we announce it, include several national laboratory-led collaborations.

My third comment and final comment on the bill is we do agree with the provisions under section 8 of S. 343, allowing the Secretary to protect information generated with industrial collaboration for up to 5 years.

Our experience in the Department of Energy, working with industry, is that companies are more willing to risk their own R&D funds cooperating with the Department if their work can be held confidential for an appropriate period.

And I would note that this provision in S. 343 is also consistent with current authority under the National Competitiveness and Technology Transfer Act of 1989.

These conclude my oral remarks.

[The prepared statement of Dr. Nelson follows:]

PREPARED STATEMENT OF DR. DAVID B. NELSON, EXECUTIVE DIRECTOR, OFFICE OF ENERGY RESEARCH, DEPARTMENT OF ENERGY

Mr. Chairman and Members of the Committee: I am pleased to be here today to discuss S. 343 entitled, "Department of Energy High-Performance Computing Act of 1991."

Before commenting on S. 343 I would like to describe the Department of Energy's roles in the High Performance Computing and Communications (HPCC) Program submitted to Congress as part of the President's Fiscal Year (FY) 1992 budget request.

The Department of Energy is an enthusiastic participant in the President's program. High performance computing is an element of the National Energy Strategy, and we believe that by working together with the other agencies and the private sector we can better achieve our requirements in high performance computing and communications, and at the same time accelerate progress in the fields of science and technology needed for DOE's missions. In a broader sense, we believe this program will have a substantial impact on U.S. competitiveness in computer technology and also on technologies that are enhanced through computational techniques such as manufacturing, chemicals and materials. In testimony on March 5, 1991, regarding S. 272 entitled "The High-Performance Computing Act of 1991," Dr. D. Allan Bromley of the Office of Science and Technology Policy, remarked on the superb cooperation among agencies in developing this integrated program that links the work of eight separate agencies into a coherent whole while retaining roles for each agency that are consistent with its mission. I share that sense of cooperation, but as current chairman of the working group under Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) that coordinates this program, I know that it has required hard work during the last four years to achieve.

Even today all of the details of the program's objectives for the next five years have not been worked out, although we certainly know them in general terms. I believe that this observation is important for today's hearing because it indicates that it will be difficult to frame law today that can govern the program over the next five years.

As Dr. Bromley has testified, legislation involving a fast-moving technological area risks "bricking in" a particular approach that may not work as technology and applications evolve during the five-year program. I would add from personal experience that the sociological and political difficulties of bringing eight agencies together for a common purpose also argues against legislation that constrains us to a particular approach.

For example, the document supplementing the President's FY 1992 Budget, entitled "Grand Challenges: High Performance Computing and Communications," describes agency technical responsibilities and agency coordinating responsibilities. As the program moves forward during the next five years, we will be determining the precise activities associated with those responsibilities. As a step in this direction we are working now on the program milestones and deliverables for each agency, as well as the interdependence of those milestones and the critical paths through the five year program. It is probable that with time and experience our current understanding of agency technical and coordinating roles will evolve. For example, we hope to involve additional agencies and programs in future years, and it might be appropriate that they take on specific technical or coordinating roles.

DEPARTMENT OF ENERGY ACTIVITIES IN SUPPORT OF THE INITIATIVE

Let me turn now to specific DOE activities in support of the President's initiative. The FY 1992 budget submission describes our plans for future years. I would like to mention today the actions that we have taken to be ready for FY 1992. Throughout our high performance computing base, DOE has cooperated with the other participating agencies to adjust priorities in a way that gives us a "quick start" on achieving initiative objectives.

Funds have been used to acquire commercial advanced architecture high performance computers for experimental study in several DOE laboratories. These funds have come from a variety of sources, but acquisitions have been coordinated to assure access to a broad range of advanced architecture computers. In several cases these computers were developed with the aid of funding from the Defense Advanced Research Projects Agency (DARPA). The results from these experimental computers have been very encouraging. Applications codes running on them are setting world records for computational speed and are already producing programmatically important results in areas such as nuclear weapons safety, global climate prediction, high energy physics, and fusion energy. As a result of our experiences and those of other users, the initiative goal to achieve sustained performance of a trillion operations per second by FY 1996 looks quite feasible.

In the area of applications we are about to announce the early start of several Grand Challenge projects in FY 1991 at the National Laboratories. We received over 20 excellent proposals, most of which have significant industrial and/or academic participation. These early-start Grand Challenge projects will help us to determine how to structure future collaborations to achieve HPCC goals.

In the area of networking, the Energy Sciences Network (ESNET) multi-protocol backbone, which connects the National Laboratories and many major universities, has been upgraded in bandwidth from 56 thousand bits per second to 1.5 million bits per second, using T1 circuits procured through FTS 2000. ESNET is compatible with and is interconnected with other Internet networks such as NSFNET, NASA's SPAN and NSI, DARPA's TWBNET and MILNET, and the regional networks. DOE coordinates its research network activities with the other participating agencies. For example, we are cooperating with DARPA, NSF, and NASA on testbeds to test higher speed networks than are currently deployed. Also with other agencies we have jointly procured circuits required for scientific collaborations with the Europeans and the Japanese, saving money compared with duplicating these circuits for each agency.

In the area of basic research and human resources DOE has begun a computational sciences fellowship program to provide urgently needed graduate training for DOE missions. We will shortly announce the first 22 fellows, chosen from over 400 applicants. Recipients will be able to choose from among those universities that have qualified programs of study in a field of computational science. Over 60 universities have already submitted applications to be qualified, and another 30 have indicated their intent to apply. We have also expanded our very successful high school student and teacher training program using the supercomputer at the National Energy Research Supercomputer Center donated by Cray Research, Inc., dedicated for the exclusive use of high school science and mathematics educational programs around the country.

REQUIREMENTS AND EXPECTATIONS

I would now like to discuss DOE's requirements and expectations of the High Performance Computing and Communications Initiative, with special emphasis on the National Research and Education Network (NREN). As I indicated at the beginning of my testimony, DOE is an enthusiastic participant in the President's initiative, because we believe that by working with other agencies that have similar needs we can increase the pace and effectiveness of our programs and better use the resources made available to us. Already, some of our preliminary cooperation in computing systems development, applications development, and networking development and deployment give evidence that this is true. This is especially true in the networking area, where we share in common with several other agencies contractors and grantees who require network access to our computers, experiments, and data bases. By working together to develop higher speed networks with better network services linked to more users, all participating agencies benefit.

However, our cooperation with other agencies must not lose sight of particular requirements that the DOE researchers have for networking. First, we must be able to provide assured, reliable, high speed access for our laboratories and for our other contractors and grantees to our computers, experiments, and data bases that are central to carrying out DOE's research missions. These resources are located at various DOE sites, and rely on ESNET for remote access. DOE must retain sufficient sovereignty over our network future to continue assuring this access, and to extend it as requirements develop. Our program would be seriously debilitated by relying on common circuits that could become overloaded by unconstrained usage. History gives numerous examples of this happening and teaches us to be cautious.

Second, DOE must retain mechanisms to involve our users in monitoring network operations. Currently the ESNET steering committee and its technical subcommittees provide the mechanism to ensure that the evolving ESNET rapidly meets users' needs. In addition, DOE conducts outside peer reviews of ESNET; the most recent in January 1991 looked at ESNET in the context of the President's initiative. The reviewers recommended a cooperative management structure for involving ESNET in the NREN, while maintaining priority on ESNET for DOE programmatic needs. They also recommended that DOE continue to manage ESNET in a way that incorporates user needs in the decision process. Finally, they recommended that DOE develop, with other participating agencies, a timely mechanism for incorporating all user requirements and for resolving conflicts regarding NREN and its component parts, and that this mechanism involve all the user communities of NREN.

Third, DOE must economize on network expenditures under current constrained budgets. This fact encourages appropriate network sharing with other agencies, but the network capabilities must be requirements driven and there must be mechanisms in place to determine and respond to usage requirements. DOE's own networking needs are determined by our agency missions.

Fourth, DOE is planning on much higher network bandwidth to meet the future requirements of the Department's researchers; we need the gigabits capacity of NREN and will work with the other agencies to achieve this. The expected long-term cost of developing a gigabits-level network precludes DOE doing it alone. However, suitable coordination mechanisms must be developed and put in place to ensure that gigabits network development priorities correspond to the needs of each participating agency. We believe that network technologies and services should be commercialized as soon as possible in a continuous technology transfer process. However, history indicates that there will be a continuing need for federal development of research networks at the leading edge. The broad commercial market for network services typically lags specialized research needs by several years. One of the NREN goals is to shrink that lag time by involving private companies in technology development and provision of network services, but the lag will probably not disappear.

COMMENTS ON S. 343 AND OTHER HPCC LEGISLATION

It is gratifying to see congressional interest in High Performance Computing and Communications. We welcome the opportunity to work with Congress to achieve the goals of the HPCC Initiative. Although we are encouraged by the legislative interest in the HPCC program shown by S. 343, we do not believe that legislation in this area is necessary especially in light of the Administration's proposal for a well defined and coordinated HPCC program in the FY 1992 budget. In fact, since the technology changes rapidly in the HPCC area, legislation would inhibit the flexibility necessary to manage such a dynamic program, to adjust HPCC research priorities, and to change direction as required to keep pace with technological innovations and discoveries.

With specific regard to S. 343, I offer three comments. First, concerning management structure, S. 343 assigns the responsibility for establishing the HPCC management plan to the Secretary of Energy. As I discussed previously, the HPCC program is a complex dynamic activity involving extensive interagency coordination. A management structure for this activity has evolved over the past four years, as the participating agencies worked together to formulate the HPCC program. Consequently, we feel that the existing interagency management structure is appropriate, without modification.

Second, concerning research and development collaborations with industry, S. 343 calls for the Secretary to establish at least two collaborative consortia to be led by national laboratories. Such consortia are already within the scope of the HPCC program as defined by the Administration. Further, the establishment and nurturing of such industrial collaborations is a high priority for all DOE programs under our Enhanced Technology Transfer Initiative, which is consistent with the National Energy Strategy. Industrial collaborations have also been established as a very high priority both at Headquarters and at the National Laboratories as part of the Department's High Performance Computing and Communications program. Indeed, as I mentioned earlier, our early start program in FY 1991 will include several national laboratory led collaborations.

Third, the provision under Section 8 (Ownership of Inventions and Creations) allowing the Secretary to protect information for up to five years, is desirable and consistent with earlier legislation. Our experience working with industry is that companies are more willing to risk their own research and development funds cooperating with the Department if their work can be held confidential for an appropriate period. This provision would be an extension of similar authorities under the National Competitiveness Technology Transfer Act of 1989 to cover other collaborative agreements with industry for the HPCC program.

I would also offer the following comments with specific regard to similar proposed legislation in the House and Senate, i.e., H.R. 656 and S. 272, as marked up by the Senate Commerce Committee last month. The drafts of these two bills are similar and the following comments apply to both:

> First, a separately legislated role for the Federal Coordinating Council for Science, Engineering, and Technology as proposed in H.R. 656 and S. 272 is not appropriate. The management structure for the Administration's HPCC program has evolved over the past several years as the participating agencies have worked together to formulate the HPCC program. This structure is appropriate as defined by the Administration HPCC program wherein the Director of the Office of Science and Technology Policy is responsible for the overall development, coordination, and evolution of the HPCC program activities.
>
> Second, H.R. 656 and S. 272 should not assign agency roles for such a program, nor should they attempt to mandate specific requirements for the interagency plan. Such mandates limit the flexibility of what is an inherently dynamic initiative. H.R. 656 and S. 272 should only request the definition and development of agency HCPP programs.
>
> Third, lead agency responsibility assignments for the National Science Foundation and for the Defense Advanced Research Projects Agency should be deleted. This restricts the Administration flexibility to alter assignments, if necessary, as the program evolves and can inhibit the participation of other agencies as they are now proposed within the Administration HPCC program for National Research and Education Network (NREN) activities and for R&D for future gigabit speed networks.

For example, H.R. 656 and S. 272 mention the Department of Energy only in passing. The DOE is a major participant in the Administration's HPCC proposal, and we must allow for DOE participation in the areas of basic and applied research in HPCC technologies, in computational science, in NREN deployment, in gigabit speed network research and development, and in educational programs as specified in the Administration's HPCC proposal.

Fourth, there is significant confusion over the meaning and requirement for commercialization of the NREN, i.e., whether this requirement is to transfer technology to U.S. industry through cooperative programs with industry, whether it requires the privatization of the NREN at some point in time, or whether it is to promote the inclusion of commercial networking services over the NREN. Since this area is confusing and ill-defined, H.R. 656 and S. 272 should only promote the transfer of HPCC technologies to U.S. industry.

Finally, H.R. 656 and S. 272 lack provisions addressing protection of commercial information produced under this program which will be needed to prevent the unauthorized or premature disclosure of critical information for U.S. industry participants in the HPCC program. The Administration has proposed other legislation in the National Energy Strategy which allows the Federal government to copyright government employee-authored computer software developed under specific cooperative research agreements and to provide for its licensing or assignment in the United States.

This concludes my testimony. I would be happy to answer questions.

The CHAIRMAN. Thank you very, gentlemen.

Both of you have testified that this problem is not broke so do not fix it. As I understand it, you do not like either S. 343 or Senator Gore's bill because both would micromanage and would specify different lead agencies in the Federal Government.

You heard our dialogue with Senator Gore. I think it is very safe to say that the Congress has a great interest in supercomputing, wants to have multi-year authorizations, wants to set some Federal goals, and yet has some differing ideas about who should manage it.

The administration does not want any direction at all. It seems to me that we need to come to some compromise here between the Commerce and Energy Committees and with the administration.

Now I wonder what parts of this bill—let me put it another way, whether you could look at S. 343 and those things that we direct, you say, you do not need to direct two collaborative consortia, you are already doing that. Well, if you are already doing it, it cannot really be harmful, and it makes the Congress feel better.

And moreover, if the Congress puts some definite goals out there, I think you might get more reaction in the private sector. They may respond and say, well, look, the administration, the Government is really serious about this and they are going to reach these goals. So therefore, we can invest in fiber optic cables, switches, all of those things that are going to take a tremendous investment.

Now, can you help us draw up a bill which will not micromanage, will give you flexibility, but will set in Federal law some goals that at least the Congress subscribes to and that you can go along with.

Dr. WONG. I certainly believe that we can, and I will do everything we can to make it happen.

Dr. NELSON. I agree with Dr. Wong. I think we do have the basis for productive legislation, by working together, and we would like to work with the Congress to see if we can achieve that.

The CHAIRMAN. Well, I wish you would do that on a very high priority basis. I think the Commerce Committee has already reported their bill. I do not know when that would be considered on the floor.

I think Science and Tech is about to report over in the House, are they not? The subcommittee marked up the bill yesterday as I understand. So before we get too far down this road—I mean, if we are going to allow for this flexibility, it would seem that that is the major hurdle.

If we can, neither freeze NSF or freeze DOE into the process, allow you to pick and choose, continue down the present road or whatever, but give you discretion. It seems to me that is the big hurdle.

Dr. **Nelson**. I think Senator Ford has made some very constructive comments on this line, Mr. Chairman.

Dr. **Wong**. Including some language, I might add, that would be useful.

Senator **Ford**. You know for a country boy to have some language that two doctors accept has made my day.

[Laughter.]

The **Chairman**. We are going to have look at it very closely.

[Laughter.]

The **Chairman**. I appreciate it very much, gentlemen. We look forward to hearing from you on it, and Senator Ford and our staff and I and all of us will be working with you on it.

Senator Ford.

Senator **Ford**. I am going to yield to Senator Bingaman. I usurped his position last time. Go ahead.

The **Chairman**. Senator Bingaman.

Senator **Bingaman**. Thank you very much, Mr. Chairman. Let me just ask a few clarifying questions, and perhaps, Dr. Nelson, this is appropriate for you.

DOE's budget is proposed to go from $65 million to $93 million I believe. How does that break down as between your office, the Energy Research Office, and the defense programs side?

Dr. **Nelson**. Senator, the amount that you allude to is all in the energy research side, and the reason for that is by no means to exclude the defense programs side. In fact, Dr. Hecker will be testifying on behalf of Los Alamos in a few minutes.

We did not want to—I will use Dr. Bromley's words—brick in the defense programs' contribution by a specific monetary amount because they have program accomplishments that they need to make.

I would point out that the experimental computers that have been purchased at places like Sandia and Los Alamos and your own State, to a considerable extent, have been funded with defense program funds. So the contribution is there. The contribution would be there in the future, but we did not wish in the Department to brick in these application specific funds.

Senator **Bingaman**. That use of funds from the defense programs side is not alluded to in this blue book. Is that right?

Dr. **Nelson**. Yes, sir. The funds, but certainly the contribution will be there.

Senator **Bingaman**. Let me ask Dr. Wong, you refer when you are talking about ESNET to a National Networking Council to coordinate networking activities among the Federal and the non-Federal community. How is that council made up?

Dr. Wong. I believe that is probably a misinterpretation. There is a Federal Networking Council made up entirely of Government employees. There will be a private sector advisory group formed pursuant to FACA guidelines. The two will coordinate, but they will be sort of complementary bodies, rather than a single entity.

Senator Bingaman. So the idea is that the National Networking Council would have as one of its duties, to coordinate with non-Federal users, but it would not have on its board or make-up any non-Federal?

Dr. Wong. That is correct. I believe the official name for it is Federal Networking Council.

Senator Bingaman. I see, instead of national, okay. Those are really the questions that I had, Mr. Chairman. Thank you.

Senator Ford [presiding]. Senator Craig.

Senator Craig. Mr. Chairman, thank you very much, both Dr. Wong and Dr. Nelson. I think by your testimony and by the conversations that we had here in the committee today that we are to a point in this discussion and concern where at least everyone has a meeting of the mind, and now the necessary language is of course key.

Dr. Nelson, you expressed some concern about the protection of DOE facilities and network and preemptive concerns. Could you broaden a little bit on that, as it relates to how you might envision the necessary language to protect and at the same time, retain the flexibility that I think we are all interested in.

Dr. Nelson. Senator, are you referring to the network access question, and of our need to preserve some sovereignty over it?

Senator Craig. Yes.

Dr. Nelson. At current, the INTERNET is made up of several networks that are separately managed and separately funded. If one thinks of the worldwide telephone system, that is also the case.

And yet, users of either the current INTERNET or the worldwide telephone system do not concern themselves too much with exactly which channel and whose company. They want to get the call through or they want to get the computer access.

Now, I am not prepared to go into specific language, but I think I can offer some principles that may help us.

Senator Craig. It is a generic discussion at this moment at least, and the willingness to cooperate with this committee in getting it is what is critical.

Dr. Nelson. Yes. I believe that the following principles might serve us. That for agency-specific or mission-specific requirements, agencies might retain separate links which could be used generally, but on a preemptive basis.

That is, if an agencies' requirements need the band width, the others do not use it. At the same time, each agency will have a lot of generalized requirements. For example, it must be—nearly all eight agencies have grants at universities like MIT.

We would be foolish to run eight separate lines into MIT, and so by a combination of some agency-specific lines or subnets and then shared lines, perhaps managed or funded by one agency, but with the overall oversight of all the agencies requiring those lines, we can build up a combination network that will serve our purposes.

And I think that it has some analogies in the current phone system, whereby today in this country even separate companies are competing along the same routes and still are managing to provide very high service.

Senator CRAIG. Thank you. I think that is what I was after, and the kind of instructive relationship we need to have at this point, to make sure that what we are doing heads us all in the right direction.

Mr. Chairman, thank you much.

Senator FORD. Thank you, gentlemen. We appreciate it. We look forward to working with you. Keep the same attitude after you leave the table as you have had at the table, will you please?

[Laughter.]

Senator FORD. The next panel will be Dr. Lloyd Thorndyke, president of Data Max, Incorporated; Dr. Glenn Ricart, president of FARNET, University of Maryland; Dr. Kenneth King, president—I am not even going to try to do that one, EDUCOM.

Dr. KING. EDUCOM.

Senator FORD. Dr. Siegfried Hecker, Director, Los Alamos National Laboratory.

Dr. Hecker, I am going to start off to the left and work to the right. We will get more conservative as we go along here.

So if you will kind of restrict your statements to just a few minutes, highlights. Each of your statements will be included in the record. We are getting squeezed for time, and I apologize for that. But I assure you, you will not go unnoticed.

STATEMENT OF DR. SIEGFRIED S. HECKER, DIRECTOR, LOS ALAMOS NATIONAL LABORATORY

Dr. HECKER. Thank you very much, Senator Ford. It is good to be back with you once again. I will do just that, I will submit my statement for the record, and I will try to highlight the comments here this afternoon.

In fact, what I will do is concentrate my remarks on what I consider the most important contributions that the Department of Energy and its laboratories could make to this initiative.

And let me just start out by saying, after listening to the conversation earlier this afternoon, go on record to say that I do not wish to manage this network that was discussed earlier. And I do not wish that Los Alamos manages this network.

In fact, what I think the short answer is, the Department of Energy, in my opinion, can make the greatest contribution by helping to shape the leading edge of computing for the increasingly demanding applications in science and technology.

And secondly, what we should do is to make certain that these advances are available to greater segments of society, particularly U.S. industry and businesses.

So in my opinion, those are the two principal objectives where DOE can make the major contribution, and I believe that these objectives could best be met by establishing and supporting several centers of excellence. And I will try to make that point here this afternoon.

As was already mentioned, there are many pieces that are required to build this high-performance computing capability. It takes much more than just the computer. You have to know how to handle and store data, and we have already discussed the aspects of a network and so forth. So there are many things that are required.

But what to me is most important, and Senator, I am sure you can appreciate that, that just like a fancy race car or great pairs of skis——

Senator FORD. Try a race horse.

Dr. HECKER. Or a race horse from Kentucky——

Senator FORD. A great race horse.

Dr. HECKER. You have to have a sophisticated and demanding user in order to be able to build the best high-performance overall computing requirement.

And I think that has distinguished the DOE laboratories, that over the years, they have had the demanding applications because of their mission, because of grand challenge problems, that have required people that know how to solve those problems.

They have had the users, and in fact, they have defined and driven the performance of the high-end of computing systems over the years.

Now, what are these demanding DOE problems? Let me just briefly state, clearly, they are the mission-oriented things such as nuclear weapons design and safety calculations. Those have, for the last four decades, driven the demands of high-performance computing.

But today they are much broader than that, all the way from environmental related activities, energy activities such as enhanced oil recovery, or in fact, the so-called grand challenge problems, whether you are talking about global climate modeling or mapping and sequencing the humane genome.

The DOE and its laboratories are involved in all of those aspects and that is where these demanding applications are. Now clearly, however, in high-performance computing, all of the Federal agencies, the ones associated with science and technologies have significant activities.

And so in my opinion no single agency should be the lead agency. This is something that a number of agencies clearly have to play their particular part that they can contribute.

It was already pointed out by Senator Johnston that Los Alamos has played a leading role in high-performance computing. In fact, from the very beginning to where today we still have the greatest scientific computing capacity anywhere in the Nation.

Let me talk a little bit about these centers of excellence. Last year, at this hearing, I proposed to you what I called collaborative research and development centers. In fact, as was just pointed out by Dr. Nelson, the centers concept is also in the Federal high-performance computing program. In that case, they are called high-performance computing research centers.

So let me just say on neutral ground, just call them centers of excellence because really the concept is the same. And before telling you what we have done, let us say since last year's testimony and just a couple of brief examples, let me first tell you what we would expect these centers to be able to do.

First of all, in this mode of a sophisticated user, we would collaborate with the computer manufacturers to make certain that we are able to take the high-performance computing capabilities to the next level.

Second, it is extremely important that we interact with the universities to make certain that the last innovations in computing and computational sciences get built into this system, and also because it is a good training ground for students.

A third and very importantly, it was already pointed out earlier today, is that these centers could develop an industrial users program which would encourage the high-performance computing capabilities getting into industry and having industry be able to enhance the manufacturing, design and processing.

Fourth, a general user program could be designed to get these capabilities out to a larger fraction of society, as was already mentioned, local communities, businesses, schools, and so forth.

Fifth, I pointed out that certain enabling technologies will drive some of the hardware aspects of the computational environment of the future, and again, the laboratories have some of the forefront capability to do that.

Just too, if I can quickly elaborate on, in this user mode of interacting, again, let us say as in race cars, race horses, skis and so forth, it is the fact that you need to interact between the manufacturer and you need to interact between the user and it takes the sophisticated user—it takes essentially a process of design, building, testing, redesigning. It is that sort of interaction which is absolutely crucial.

And again, we have played that role for a number of years. But just in this past year, what I am particularly proud of is that we again have played that role with the Thinking Machine Company's Connection Machine. And that is, we have been able to take these massively parallel processing machines, over 65,000 processors working on the problem in parallel and we have been able to solve real world problems with those machines.

In fact, let me just give you an idea of the type of problems. We have solved some in looking at oil reservoirs, enhanced oil recovery. We have worked with Chevron Oil Field Research and have been able to have them increase their capability of doing this reservoir modeling.

In fact, Danny Hillis, who is the founding scientist of Thinking Machines, has recently said that Los Alamos has, by taking the leadership role in the application of parallel super computers proved to the scientific community that the Thinking Machines' approach to high-performance computing is applicable to an extremely wide variety of real world applications.

So much as the role we played with Cray supercomputers and we continue to play, we have played a similar role with these new massively parallel processing computers.

Now clearly, I mentioned the computers. There is much more to the overall computing environment than just computers. And that is, we have mentioned software, data systems, et cetera.

In order to make this environment be truly useful, what we will need to do is make certain that the interface between this user and the system, this computational system is as seamless or transparent as possible.

And what I mean by that is we would like to be able to access these enormous capabilities of a facility like Los Alamos, essentially with the touch of a mouse on a desktop. So that the user actually does not have to worry about all of the complications of hooking up with this capability.

So a principal goal then of the centers is to make certain that we push this computational environment to the limits.

Now in addition to shaping this leading edge, I mentioned the importance of the industrial connection, and my statement includes a number of examples, but really spurred by last year's testimony, Senator Bingaman, where you made the observation after hearing John Rollwagon's statements, CEO of Cray, that if you take away aerospace usage and government usage of computers, of super computers in the United States and you compare United States and Japan, you find that the rest of Japanese industry essentially uses twice as many super computers as the United States.

So you expressed your concern that maybe the rest of industry in the United States is not keeping up with the latest capability. But we work very closely with Cray Research Corporation, and in fact, after the conference we had at Los Alamos on the frontiers of supercomputing, to see whether we can change that situation to work closely with the computer vendor or manufacturer such as Cray or in fact a number of others that we are working with, Thinking Machine and so forth.

And so we have developed a collaboration which reaches out and essentially performs this experiment where we reach out and interface with a much greater segment of U.S. industry.

And so we have a number of these collaborations going. We are also working with Dupont. In fact, Dupont has an industrial staff member at our advanced computing laboratory at Los Alamos, learning how to use this highly massively parallel processing capability that we have at Los Alamos.

So we have launched a number of those initiatives. Clearly, the legislation and the creation of the centers with the goal of working more closely with industry and the capability that we now have at the laboratories of signing CRADA's, that is the Cooperative Research and Development Agreements. I think that would expedite that situation significantly.

So let me just wrap up with a few comments of what I see these centers being. I already told you the objectives. I think clearly there will only be a few of those, since we are talking about them being at the leading edge.

And this is especially true since the next generation of these machines and the rest of the hardware are going to be very expensive, very people intensive, in terms of being able to produce something useful with that.

They must be collaborative, in conjunction with universities, as well as industry, and I think they could be geographically distributed with a lead organization, with several other participants across the country.

And in fact, it is that geographic tie which brings me to my final comment on networking. We have had a lot of discussion here about the highway aspects of the network. But clearly, the most important thing for the network is the same for the super computers: They are only useful if you can do something with them.

So the input/output or the on and off ramps of that are really crucial. And so again, the most important aspect of the network is the interaction of the user with the design and operation of that network, and the part where the centers or the institutions could really contribute in making certain that the network then is able to service the requirements of the different users, and clearly the different agencies have different requirements.

Such as DOE very much on the high end as I have explained; NSF, for instance, serving this great multitude of users.

So to sum it up, there is no question in my mind, the Department of Energy and its laboratories can continue to help to push the leading edge in computing.

But I think these centers of excellence can make certain that they shape the leading edge, and provide then this greater useful computing capability to U.S. industry, businesses and universities as well.

Thank you very much for allowing me to share my views with you, Mr. Chairman.

[The prepared statement of Dr. Hecker follows:]

Prepared Statement of Dr. Siegfried S. Hecker, Director, Los Alamos National Laboratory

EXECUTIVE SUMMARY

High-performance computing (HPC) is a critical strategic technology vital to the long-term scientific and economic leadership of the United States. The Department of Energy (DOE) and its laboratories have played an important role in developing high-performance computing because of the need to solve complex computational problems stemming from demanding DOE applications. This experience places the DOE laboratories in an excellent position to help keep the United States at the leading edge of computing.

The pervasive importance and dynamic nature of the computing field suggests that DOE's overall response should be integrated within a larger, coordinated Federal government effort. A special feature, if not the focal point of the DOE initiative, should be the establishment and support of a few centers of excellence that shape the frontiers of this strategic technology. The centers should feature extensive interactions between computing manufacturers and center researchers who define and develop the computational environment for future demanding applications. At the Los Alamos National Laboratory, we have performed this role historically. Recent experience with our Advanced Computing Laboratory demonstrates that we continue to play this role today in the application of massively parallel machines. Featuring early production high-performance computers, the centers of excellence would build the computational environment essential to the advancement of the state of the art in problem solving. Such an environment includes: massive data storage and retrieval, ultrahigh-speed graphics, advanced numerical algorithms, software, networks and interfaces, and user-friendly terminals. The latest innovations will be incorporated not only through the computer manufacturer interface, but also via close ties with academia.

A second major feature of the centers should be the dissemination of this problem-solving capability to a greater fraction of society. To compete with and complement the increasing power of stand-alone (personal) computers, the interface between the user and the high-performance environment must be made as transparent as possible: that is, it should be accessible with the touch of a mouse. The most important element of the expanded user community has to be U.S. industry, but it should be followed by businesses, schools, local communities, and eventually households.

The centers of excellence should be collaborative (with universities and industry as noted) and they should be distributed, comprised of a lead institution, several principal participants, and a number of affiliated organizations. Finally, because of the rapidly changing environment, the DOE should have maximum flexibility in establishing and adapting the centers to changing times and requirements.

I will discuss three matters in my remarks today. First, I will review some of the reasons why I support the concept of a coordinated national effort in high-performance computing (HPC). Second, as an example of the important role that the Department of Energy (DOE) and its national laboratories are already playing in HPC, I will review the HPC efforts at Los Alamos National Laboratory. Finally, I will suggest how the DOE role in a coordinated national effort can be enhanced.

THE NEED FOR A NATIONAL HIGH-PERFORMANCE COMPUTING INITIATIVE

I believe that there is no end in sight to the revolution we call the computer age. Better performance will enable scientists and engineers to solve increasingly complex problems. High-performance computing has yet to make its greatest impact on business, industry, and on our everyday lives.

The technology supporting high-performance computing has grown rapidly. Over the past forty years, some applications have enjoyed an increase in computing speed of ten billion, or ten orders of magnitude. This increase has come in almost equal parts from advances in computer hardware and from more sophisticated software and numerical algorithms. In the past few years, it has became increasingly apparent that new algorithms and massively parallel computer architectures offer the greatest potential for dramatic performance improvements. With increased speed has come the recognition of other significant requirements for large-scale computing:

Real-time visualization,

High-speed networking to provide convenient and powerful computing capability at your desk,

Software tools to facilitate writing sophisticated scientific computer programs.

High-performance data storage, retrieval, and analysis.

In testimony before this Committee last year and in response to follow-up questions for the record, I argued that high-performance computing is a critical strategic technology that contributes to U.S. military and economic strength and benefits the quality of life, and, therefore, is of such pervasive importance to the United States as to demand continued strong leadership. Such leadership, I stressed, could only be maintained with enhanced funding levels and greater interagency coordination. I emphasized the critical need to establish a few centers of excellence (which I called Collaborative R&D Centers) in HPC that keep the United States at the leading edge of high performance computing. Such centers would meld the experience and expertise resident at DOE laboratories with that at universities and U.S. industry. The centers would be an excellent vehicle to help provide more useful supercomputing capability to a greater fraction of our society. This approach is in general agreement with the Federal High-Performance Computing and Communications (HPCC) Program and S. 343.

As pointed out in S. 343, the DOE is an agency with great depth of knowledge in and dependence upon all aspects of high-performance computing and communications. HPC is, however, such a fast moving, technically demanding, and broad field that no single agency should be expected to play lead role. Indeed, substantial progress in this field requires the coordinated efforts of several government agencies, agencies that have both extensive HPC experience as well as mission-specific computing requirements.

It is most important that high-performance computing requirements be driven by applications. Such applications include the demanding requirements of U.S. industry and the mission requirements of Federal agencies. (For example, the challenging problem of nuclear weapons design has driven and defined HPC requirements for decades.)

Among the most demanding applications today are the "Grand Challenge" problems. These consist of fundamental problems whose solution is critical to national needs and include: modeling of global climate change; understanding turbulence, pollution dispersal and combustion; designing new molecules, pharmaceuticals, and materials; determining molecular, atomic and nuclear structure; mapping the human genome and understanding biological structure; etc. Tackling these applications requires the most advanced computational and communications resources—a high-performance computational environment that must be continually updated to include a combination of the most powerful number-crunching capabilities, rapid and efficient data storage and retrieval, visualization and analysis techniques, and high-speed networks.

An interagency format is appropriate for this program because each agency has its own particular areas of focus, interest, and strength. For example, the National Science Foundation continues to support very innovative basic research in computational science and computing concepts. The Defense Advanced Research Projects Agency (DARPA) has helped to pioneer new hardware and software for massively parallel processing. The Department of Energy and NASA have been instrumental in using the latest generation high-performance computers to solve demanding mission-oriented problems. The DOE, through several of its laboratories, has been instrumental in developing a high-performance computing environment that makes this possible. An important part of that environment is a high-speed network—DOE's Energy Sciences Network (ESNET), which connects its laboratories with universities across the nation.

The DOE has mission-oriented needs which will require multigigabit per second single-application access to a national network. In contrast, the National Science Foundation is interested in supporting a broader user community but at much lower individual rates. Consequently, a national network will have to address a variety of requirements and users. Therefore, this capability must be planned, implemented, and managed in the national interest as a cooperative venture, rather than by any one particular agency.

Increased U.S. industrial competitiveness must be a fundamental goal of any national-level effort in HPC. This is an explicitly stated goal of the Federal HPCC program and, in my opinion, should also be specifically mentioned in S. 343. The current business climate does not encourage corporate America to invest sufficiently in enabling technologies for which the payoff is long term and less immediately oriented toward marketable products. For the United States to continue to hold a primary position in the international economic community, it will be important to develop a forward-looking strategy with respect to the use of computers for research, for advanced simulations, and for engineering design. We believe that the S. 343 concept of national centers of excellence will provide an excellent vehicle for working with industry in demonstrating the value of modern computational resources, developing desired industrial expertise, and providing appropriate technology for solving industrial applied problems.

LOS ALAMOS ROLE IN HPC

Supercomputing originated with the "Los Alamos problem," as predicting the performance of the first atomic bomb was called during the Manhattan Project. We actually designed and built one of the world's first large-scale electronic computers, the MANIAC. Over the past 40 years, we have worked with leading supercomputer manufacturers including IBM, Control Data Corporation, Cray Research, Inc. (CRI), and most recently Thinking Machines Corporation (TMC).

Our role has been that of a sophisticated user with the goal of maximizing the productivity of the individual. In that capacity, we often develop new software and algorithms to solve complex problems. And occasionally we even develop new hardware.

In 1976 Seymour Gray brought his first Gray-1 to Los Alamos without software and with no operating system. We helped him bring it on line for large-scale problems. At last years hearing, John Rollwagen, Chairman and CEO of Gray Research Inc., put the role of DOE and Los Alamos in perspective with his comment, "Gray would not exist if it were not for DOE and Los Alamos."

Today, Los Alamos is the most powerful scientific computing center in the world with the equivalent Gray power of about 50 of the original Gray-I computers plus the two largest Connection Machines ever produced, serving more than 8,000 users throughout the nation via a national computing network. But it is our own computationally intensive applications, starting with the complexity of designing nuclear weapons and now including a wide range of programs critical to emerging national and global challenges such as energy, environmental, and economic concerns, that require us to remain at the leading edge of computing technology.

RECENT PROGRESS AT LOS ALAMOS—THE ADVANCED COMPUTING LABORATORY

In 1988, Los Alamos established the Advanced Computing Laboratory (ACL). It has been a catalyst for leading-edge research in the technologies that comprise an HPC environment. The current focus is on demanding applications using the second-generation Thinking Machine Corporation's (TMC) Connection Machine which has 65,536 processors, 8 gigabytes of memory, 4 frame buffers and monitors, a high-performance parallel interface (HIPPI), and a 20-gigabyte data storage system.

Over the past two years Los Alamos and TMC have demonstrated that many of today's greatest computational challenges can be met with the massively parallel processing approach afforded by the Connection Machine. Los Alamos researchers are now routinely solving scientific and technological problems beyond our reach just a year or two ago. A few examples follow.

Novel numerical algorithms have been developed at Los Alamos which are almost perfectly suited for the massively parallel architecture of the CM-2. For the first time anywhere, using the synergism of computing resources and the resident expertise at Los Alamos in computer science and mathematics, we have been able to successfully simulate very complex, small-scale fluid flow through porous media such as sandstone and other oil-bearing rock.

Today, Mobil, Chevron, and Amoco are working with us in research collaborations using this computational technology to interpret experimental data gathered to enhance oil recovery. In a recent letter, E.W. Jones, President of Chevron Oil Field Research Company, complemented the effort by stating:

> Through our interaction with LANL's researchers, the Advanced Computing Laboratory, and the Numerical Computing Laboratory, we were able to successfully test run a reservoir simulation model with over two million grid Points using LANL's Connection Machine recently. This size of reservoir model is about two orders of magnitude larger than those typically used in the oil industry. With this new capability, we will greatly improve the geologic definition of the reservoir models, which recent research has shown to be vital in predicting reservoir performance.

In the area of global climate change and in collaboration with the National Center for Atmospheric Research and the Naval Postgraduate School, Los Alamos has developed a global ocean model significantly more accurate than previous models. The significance is that scientists are now realizing the greater importance of ocean flows and ocean eddy currents to the overall global climate system. Again, this model was an outgrowth of the combination of theoretical expertise in oceanography and expertise in using the attributes of the massively parallel Connection Machine: this effort resulted in the first implementation of a global ocean circulation model on a massively parallel computer. It is only with the parallel architecture of the Connection Machine and its large memory that this more accurate model was possible.

Los Alamos is also actively involved in global change studies with other University of California institutions. The main thrust of this project is to perform research contributing to the development of an advanced, coupled atmosphere-ocean climate model that takes advantage of high-performance computing. To date, this work has been done principally on our top-of-the-line Cray Y/MPs. The project is a three-way collaboration with Los Alamos, the Scripps Institution of Oceanography, and the Lawrence Livermore National Laboratory; the project has been expanded to include all nine of the University of California campuses—a fact which reflects both the success of the project and the increasing interest in global climate change. Graduate and postdoctoral students play a significant role in this research.

Assuring the safety of the nation's nuclear stockpile is one of the key responsibilities of the DOE nuclear weapons program. Fulfilling this responsibility requires the extensive use of computer modeling to simulate the behavior of nuclear weapons components in possible accident environments. The complexity of such scenarios, involving difficult three-dimensional geometries, complicated physical phenomena, and great sensitivity to small changes, has always placed extreme demands on available simulation capability. Recent advances in parallel computer architectures and the development of innovative numerical techniques have now provided a new level of capability for three-dimensional simulations of nuclear weapons safety issues. A most important component to this capability has been the expertise of Los Alamos scientists in the development of the free-Lagrange hydrodynamics method and its implementation on the Connection Machine.

These examples demonstrate our continuing role in shaping the leading edge in high-performance computing applications. Adding his support is Danny Hillis, Founding Scientist of TMC, who in recognizing the continuing critical role played by Los Alamos asserts: "Los Alamos has, by taking a leadership role in the application of parallel supercomputers, proved to the scientific community that the Thinking Machines approach to high performance computing is applicable to a wide variety of real world applications."

But supercomputers themselves do not represent the only area in which Los Alamos has close ties to the computing industry. The High-Performance Parallel Interface (HIPPI) was conceived and designed at Los Alamos to satisfy our requirements for very high-speed networking, including communications between supercomputers and real-time visualization of scientific computations. This innovation is becoming an industry standard, with more than sixty computing vendors showing interest: almost two dozen different manufacturers are already building HIPPI-based equipment. These include CRI, IBM, TMG, Ultra Network Technologies, Network Systems Corporation, IPITEK, and Broadband Communications Products.

The recent developments discussed above allow large amounts of data (for example, the results of a computer simulation) to be transferred through a network in a reasonable time. However, an obstacle that still remains in supporting grand-challenge applications is to provide data storage capabilities that allow the massive amount of data generated to be stored in a timely and reliable manner, and that allow the data to be easily retrieved for analysis and display. Such a high-performance data system will be the successor to the Common File System, a Los Alamos designed and implemented system now marketed by General Atomic. Even as efficient, fast, and successful as the Common File System is, some current applications generate so much data that it can take several hours just to store the data plus several more hours to retrieve it for use in another calculation. IBM will be a major industrial collaborator in this new project.

Progress was also made in several of the other objectives for centers of excellence. Los Alamos continues to work closely with universities to bring the latest innovations to bear on solving demanding computational problems. We are proud to be a part of the NSF Science and Technology Center for Research on Parallel Computation. Charter members are Rice University (lead), Caltech, Los Alamos, and Argonne. The Center's goal, to make parallel computation truly usable, and the Los Alamos goals for HPC are truly synergistic. Our participation in this collaboration provides the Laboratory with access to innovative software to incorporate in our high-performance computing environment and provides the Center with a unique, full-scale testbed for the tools developed as part of that research effort.

Last year I proposed that centers of excellence sponsor graduate research assistantships in computational science to increase support for students in this important field. The Scientific Computing Staff at DOE has just established such a Computational Science Graduate Fellowship Program through Oak Ridge Associated Universities. The response has been overwhelming with 400 applicants for the 22 positions created in FY91.

Last year's hearing highlighted the need for greater utilization of HPC by U.S. industry. This theme was echoed in the Frontiers in Supercomputing II Conference (held in Los Alamos in August 1990 and cosponsored by Los Alamos, the National Security Agency, DOE, NASA, NSF, and DARPA).

We at Los Alamos have launched several initiatives to enhance industrial participation. In November 1990, Los Alamos and Gray Research Incorporated jointly sponsored a two-day applications symposium. The main purpose of this workshop was to develop a broad-spectrum collaboration between the two organizations. Five initial collaborative projects of interest to both parties have resulted to date:

Automotive engine combustion code development
Integrated simulation tool
High-resolution global climate modeling
Computational chemistry
Computational electromagnetics in ultra high-speed electronics design

Nine additional areas of potential collaboration have been identified. In addition, cooperative projects have been initiated with CRI in advanced networking, massively parallel processors, and supercomputing education.

We propose to use this basic approach, suitably modified for each interaction, to generate broad collaborations between Los Alamos and industry. For example, together with a researcher from DuPont who is working in our Advanced Computing Laboratory for two years, we have been actively pursuing a DuPont/Los Alamos symposium. A host of other industrial collaborations is also being pursued.

Educational outreach is a most important aspect of bringing useful high-performance computing to a greater fraction of society. Last year Los Alamos, Sandia, New Mexico Technet and several private sector companies initiated a special experiment we call the New Mexico Supercomputing Challenge. This is an academic-year long competition that provides teams of high school students throughout New Mexico with the opportunity to become involved in computational science projects using high-performance computers. The purpose of this Challenge is to expose students and teachers to the tools and mechanisms to solve difficult problems typically not possible in high school classes. The enthusiastic response from New Mexico schools—235 students and 55 teachers in 65 teams from 40 schools in the first Challenge alone—demonstrates significant interest, motivation, and untapped potential for science education at the high school level. We would like to expand this program under the aegis of the Federal HPCC program to other states next year.

POTENTIAL FOR AN ENHANCED DOE ROLE

The future computing environment will continue to evolve in unforeseen ways in response to new requirements and opportunities. The Federal HPCC initiative correctly points out that many Federal agencies must contribute and that their efforts must be coordinated with U.S. industry, universities, and national laboratories. I will concentrate only on a potential DOE role since that is the focus of S. 343.

The DOE continues to require the application of leading-edge high-performance computing for its mission requirements in defense, energy, environment, and basic research along with grand-challenge scientific problems. Consequently, I believe that the DOE's principal focus should be to help shape the leading edge of high-performance computing. As already pointed out, Los Alamos has always played a strong role in this area. We have accomplished this in the past almost entirely with the financial support of the nuclear weapons program. That is no longer appropriate, nor possible today, since our contributions now cover a much broader spectrum, ranging from the human genome project to enhanced oil recovery.

In addition, the DOE can contribute significantly to putting a more useful computing capability into the hands of U.S. business, industry, and a broader segment of society. A computing environment that is friendly and available to large segments of our population would likely change the entire fabric of American life. Business decisions and operations already depend largely on computing, but complete connectivity and access to national data bases with powerful computers and high-speed networks would increase their productivity and hence the nation's international competitiveness. Access to data bases could influence daily decisions that vary from health care and diagnosis to automobile repair. The DOE laboratories have developed an extremely productive collaborative relationship with U.S. computing manufacturers that would serve as a starting point. In addition, they have also established a groundwork of educational initiatives that reach out to students early in their careers.

RECOMMENDATION

Both of these objectives are incorporated into the concept that I presented to this committee last year, the Collaborative Research and Development Centers for HPC. Similar "centers of excellence" are featured in the Federal HPCC program and referred to as High-Performance Computing Research Centers. I remain convinced that "centers of excellence" for HPC should be the cornerstone of the DOE's response to the Federal initiative. The Department should also support the science associated with grand-challenge problems and bring greater computing capabilities to all of its researchers through advances in hardware, software, and networks.

The Centers Concept

Centers of excellence at DOE laboratories would continue to shape the leading edge of computing and promote greater access to useful HPC capabilities. The objectives of the centers should be to:

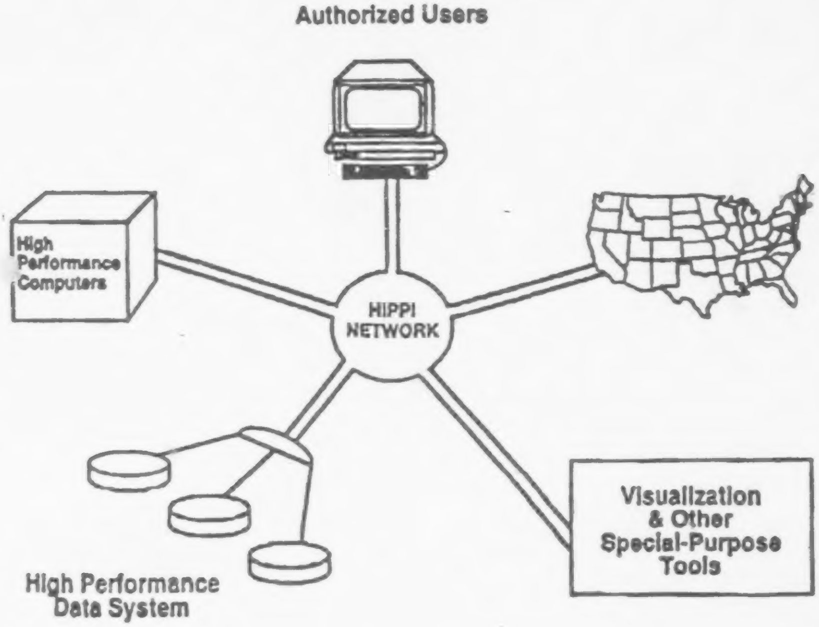
1. Collaborate with computing manufacturers to develop the high-performance computing environment of the future (including high-speed communications and protocols) by solving demanding grand-challenge problems;
2. Collaborate with academia to continue to bring the latest innovations into this environment and to offer a training ground for students;
3. Develop an industrial user program to encourage greater use of HPC capabilities for industrial design, manufacturing, process enhancement, and business applications;
4. Develop a general user program designed to provide user-friendly computing through networks to local communities for business, secondary schools, and universities; and
5. Develop enabling technologies for high-performance computing in conjunction with U.S. industry and with other Federal agencies such as DARPA.

DOE Centers of Excellence for HPC

The accomplishments at Los Alamos this past year demonstrate that the Advanced Computing Laboratory can serve as a model for DOE centers of excellence.

The principal focus of the centers of excellence should be to keep the United States at the leading edge to solve increasingly demanding problems of science and technology. This can be best accomplished through extensive interactions with computing manufacturers and by solving grand-challenge and other demanding mission-oriented problems. Solutions to these problems continue to demand a computational environment considerably beyond the capabilities that exist today.

In the future, we envision a high-performance computing environment that distributes the individual components, including massive computing capabilities; systems and applications software developed for specific architectures; data systems that enable the storage, retrieval and analysis of staggering amounts of data, all tied together with a high-speed network. These pieces will be integrated into a single, logical environment that permits the researcher to easily manage the problem across the disparate elements. The basic components of this environment are shown in the figure below.


Authorized Users
High Performance Computers
HIPPI NETWORK
Visualization & Other Special-Purpose Tools
High Performance Data System

The high cost of the next-generation hardware and the extensive people resources required will dictate that only a few such centers of excellence continue to define the leading edge. The centers would not only continue to push the frontiers of this computational environment by incorporating the latest hardware or advances in software, but also make the interface between the user and this environment as seamless or transparent as possible. A goal should be to make the power of a supercomputer accessible through the touch of a mouse on a desktop. This way, high-performance systems will continue to provide a high-end alternative to increasingly powerful stand-alone (personal) computers.

Developing the computation environment of the future will require effort on all five objectives listed above for centers of excellence. However, effort should be focused immediately on the first objective: collaborating with computer manufacturers to develop the HPC environment of the future by solving demanding grand-challenge and mission-oriented problems. As we pointed out last year, this will require:

Challenging computer performance and computing tools with demanding applications.

Identifying requirements for suppliers and inventors.

Testing this new computational environment, integrating new architectures, software, and visualization.

Developing software, hardware, algorithms, etc., in collaboration with high-performance computing manufacturers.

Helping develop and test new distributed networking systems.

Disseminating knowledge and experience gained to others.

I believe that the centers of excellence will be most effective as collaborative and distributed centers comprised of a lead institution, several principal participants, and a number of affiliated organizations; a center of excellence is in effect a team of several organizations. While individual sites will make important contributions, the geographically distributed nature of the national computing resource must be key in the organization of the center itself. Thus, high-end use of networking and other technologies by a center of excellence to effect distributed computing will play an important role in the broader goal of developing efficient and distributed massively-parallel computing over a large geographical area.

Centers should be established at a few leading institutions, those that currently have outstanding computing facilities, significant grand-challenge and mission-oriented problem-solving programs, and track-records of working successfully with computing manufacturers as well as U.S. industry, in general. Since computational science is such a rapidly moving field it would be wise to provide the DOE with the maximum flexibility in establishing and operating its centers.

Thank you for the opportunity to share my views on the future of high-performance computing and the role that DOE and its laboratories can play.

Senator FORD. Thank you, Doctor.

Dr. King.

STATEMENT OF DR. KENNETH M. KING, PRESIDENT, EDUCOM

Dr. KING. Senators, it is a pleasure for me to respond to your invitation to testify before the committee on S. 343, the Department of Energy, High-Performance Computing Act of 1991.

I represent EDUCOM, an association of over 600 American colleges and universities, working on the goals of creating a national information technology infrastructure and using information technology to improve intellectual productivity in teaching and learning.

I also represent the partnership for the National Research and Education Network, a group of associations and corporations which is supporting the creation of a national research and education network.

The last several years have seen rapid progress toward the NREN. This is in large measure the result of cooperative efforts among many groups. In Washington, Federal agencies under the direction of the White House Office of Science and Technology Policy and the Federal Coordinating Committee for Science, Engineering and Technology have played important roles in planning the NREN and expanding existing research networks.

The National Science Foundation has created and managed the highly successful NSFNET. Universities have cooperated with each other and with State agencies to form more than 20 regional and State research and education networks, and have made large investments in the hundreds of millions of dollars to build computer networks on their own campuses, so that the faculty and students may have the widest possible access to network resources. A continuation of such collaboration is essential.

As I understand the intent of the committee bill, S. 343, the Department of Energy would be directed to create an advanced nationwide computer network for use by all Federal agencies and departments in their research and education programs.

The language of 6.A, section 1 of S. 343 is not clear as to the relationship such a DOE-sponsored network would have with the administration's high-performance computing and communications program, nor with the high-performance computing bills currently under consideration by the Senate and House research committees.

I believe that the best thing your committee could do to improve our national leadership in advanced computing and networking would be to amend this bill so that it fully supports the goals of the administration's program.

It is critically important that the scientific and technical resources of the Department of Energy be part of an ongoing partnership effort with other Federal agencies, universities, libraries, and industry, to create the NREN and to ensure the best possible computing and networking facilities are made available for national research and education efforts.

In particular, I would like to support all of the initiatives there were outlined by Dr. Hecker for the Department of Energy.

You asked that I testify specifically on the proper management structure for the National Research and Education Network, and I will devote the remainder of my statement to that subject.

There are many management challenges faced by those engaged in building the NREN, but the following are key priorities. Maintaining the momentum already achieved, and expanding access to the existing interim NREN network for those parts of the research and education communities that are not currently connected.

Developing production gigabit network technology and placing it into service in the NREN; making the transition from the current informal management structure to one capable of effectively operating the nationwide high technology service enterprise.

I believe that Congress can support the management needs of the NREN best by adopting a set of basic principles, rather than a detailed and prescriptive list of legislative directives.

These principles should include a commitment to a distributed management structure which deals with problems and issues as close to the network user as possible; a participant policy making body which can balance the interests and guide the efforts of Federal, regional, State, and local interests in the NREN; a network funding strategy which supports the NREN goal of broad access for research and education.

Based on the experiences of a wide variety of university library and industry users of NSFNET over the last several years, an NREN policy framework was developed by the partnership for the NREN and forwarded to this and other relevant congressional committees in January 1991.

A copy of the statement and its covering letter listing the members of the partnership is appended. With respect to management, the policy framework recommends the establishment of an independent entity which could be a board or a federally chartered activity whose task would be to set and administer policy and to guide planning for the NREN.

The administration's high-performance computing and communication program proposes the creation of a National Network Council, NNC, with participation by both Federal and non-Federal network users and providers.

Subject to further definition of the role and responsibility of this body, its creation seems to be a reasonable next step in the evolution of a management structure for the NREN, and we believe your committee should support the NNC proposal.

In conclusion, I would like to emphasize two points. First, the university community views the creation of the NREN as absolutely essential to its role in advancing science research and education and is already made some substantial financial and programmatic investments in the campus computer networks which are necessary to reach the faculty, students and research staff users of the NREN.

These investments provide an unprecedented means to leverage a major Federal and State program to meet important national goals in research, technology transfer, and economic competitiveness.

Second, the long-term success of the NREN will be measured by the extent to which it meets a wide range of needs in research and education, needs which transcend the boundaries of individual Federal agencies and whose fulfillment requires a working partnership among government, education and industry.

I hope that in the markup of S. 343, the committee will revise the language of the bill to provide that the Department of Energy will be a full partner in the team effort to create the NREN.

Thank you.

[The prepared statement of Dr. King follows:]

PREPARED STATEMENT OF DR. KENNETH M. KING, PRESIDENT, EDUCOM

Senator Johnston, it is a pleasure for me to respond to your invitation to testify before the committee today on S. 343, the Department of Energy High Performance Computing Act of 1991. I represent EDUCOM, an association of over six hundred American colleges and universities working on the goals of creating a national information technology infrastructure and using information technology to improve intellectual productivity and teaching and learning. I also represent the Partnership for the National Research and Education Network, a group of associations and corporations which is supporting the creation of a National Research and Education Network (NREN).

The Department of Energy has distinguished itself over many years in supporting high performance computing and networking. It is doubtful that the leadership in supercomputers which the United States enjoys today would exist if the national laboratories under DOE and university sponsorship had not devoted significant resources to their development. It is therefore entirely appropriate that the Department play a major role in the federal High Performance Computing Program and especially in the creation of a National Research and Education Network (NREN).

The NREN is an ambitious undertaking. It requires high technology, some of which is not yet developed; a nationwide operational infrastructure of advanced communications facilities; and a working partnership of many organizations and individuals from government, education and industry. The ultimate aim of the NREN is to pave the way for the electronic national information infrastructure which will form the communications base for our economy in the 21st Century.

The last several years have seen rapid progress toward the NREN. This is in large measure the result of cooperative efforts among many groups. In Washington, federal agencies under the direction of the White House Office of Science and Technology Policy (OSTP) and the Federal Coordinating Committee for Science, Engineering and Technology (FCCSET) have played important roles in planning the NREN and expanding existing research networks. The National Science Foundation has created and managed the highly successful NSFNET. Universities have cooperated with each other and with state agencies to form more than twenty regional and state research and education networks, and have made large investments—in the hundreds of millions of dollars—to build computer networks on their own campuses so that faculty and students may have the widest possible access to network resources. A continuation of such collaboration is essential.

As I understand the intent of the committee bill, S. 343, the Department of Energy would be directed to create an advanced nationwide computer network for use by all federal agencies and departments in their research and educational programs.

The language of Section 6(a)(1) of S. 343 is not clear as to the relationship such a DOE sponsored network would have with the Administration's' High Performance Computing and Communications Program (HPCC), nor with the High Performance Computing bills currently under consideration by the Senate and House research committees.

I believe that the best thing your committee could do to improve our national leadership in advanced computing and networking would be to amend this bill so that it fully supports the goals of the Administration's program. It is critically important that the scientific and technical resources of the Department of Energy be part of an ongoing partnership effort with other federal agencies, universities, libraries and industry to create the NREN and to ensure that the best possible computing and networking facilities are made available to our national research and education efforts.

Since 1986, DOE has been an active participant in the interagency planning for the NREN. In the recently announced HPCC plan, the department has been assigned important networking responsibilities, including integration of its advanced ESNet into the NREN and development of energy mission-related applications for the NREN. This role is an important one to the success of the HPCC program, and I hope that the committee will take steps to ensure a continued high level of participation in its program authorization legislation. In particular, we believe that the Department of Energy could make major contributions to the creation of the NREN if it were authorized and funded to expand its program of research and development in network security, use of large databases in networks, and parallel processing of large computational problems on networked supercomputers.

Additionally, we believe that Secretary Watkin's initiatives in extending a helping hand to science and mathematics education at primary and secondary education levels, which can be materially assisted by extending NREN connections to K-12 schools, deserves the support of your committee.

Mr. Chairman, you asked that I testify specifically on the proper management structure for the National Research and Education Network and I will devote the remainder of my statement to that subject.

There are many management challenges faced by those engaged in building the NREN, but the following are key priorities:

Maintaining the momentum already achieved and expanding access to the existing Interim NREN network for those parts of the research and education communities that are not currently connected;

Developing production gigabit network technology and placing it into service in the NREN;

Making the transition from the current informal management structure to one capable of effectively operating a nationwide high technology service enterprise.

A successful management strategy for the NREN for the near term must emphasize flexibility and quickness of response. No single model is likely to be adequate to guide the management of the network over the next five to ten years. I believe that Congress can support the management needs of the NREN best by adopting a set of basic principles rather than a detailed and prescriptive list of legislative directives. These principles should include:

A commitment to a distributed management structure which deals with problems and issues as close to the network user as possible.

A participative policy making body which can balance the interests and guide the efforts of federal, regional, state, and local interests in the NREN;

A network funding strategy which supports the NREN goal of broad access for research and education;

Based on the experiences of a wide variety of university, library and industry users of NSFNET over the last several years, an NREN Policy Framework was developed by the Partnership for the NREN and forwarded to this and other relevant Congressional committees in January, 1991. (A copy of the statement and its covering letter listing the members of the Partnership is appended.) With respect to management, the Policy Framework recommends the establishment of an independent entity, which could be a Board or federally chartered activity, whose task would be to set and administer policy and to guide planning for the NREN.

By way of example, critical issues which will require study and review by all of the NREN constituencies—federal as well as non-federal—include policies for access, technical standards for interconnection and interoperability, rules for accounting and plans for service enhancements.

The Administration's HPCC program proposes the creation of a National Network Council (NNC), with participation by both federal and non-federal network users and providers. Subject to further definition of the role and responsibility of this body, its creation seems to be a reasonable next step in the evolution of a management structure for the NREN and we believe your committee should support the NNC proposal.

In conclusion, I would like to emphasize two points. First, the university community views the creation of the NREN as absolutely essential to its role in advancing science, research and education and has already made substantial financial and programmatic investments in the campus computer networks which are necessary to reach the faculty, student and research staff users of the NREN. These investments provide an unprecedented means to leverage a major federal and state program to meet important national goals in research, technology transfer and economic competitiveness. Second, the long term success of the NREN will be measured by the extent to which it meets a wide range of needs in research and education, needs which transcend the boundaries of individual federal agencies and whose fulfillment requires a working partnership among government, education and industry. I hope that in the markup of S. 343, the committee will revise the language of the bill to provide that the Department of Energy will be a full partner in the team effort to create the NREN.

EDUCOM,
Washington, DC, January 25, 1991.

Hon. J. Bennett Johnston,
Chairman, Energy and Natural Resources Committee,

Hon. Malcolm Wallop,
Energy and Natural Resources Committee,

Hon. Wendell Ford,
Chairman, Subcommittee on Energy Research and Development

Hon. Pete Domenici,
Subcommittee on Energy Research and Development.

Dear Senators: The Partnership for the National Research and Education Network is writing to request your support of legislation for a high capacity national computer network to serve a broad range of research and education purposes The Partnership, whose current members are listed below, encompasses a number of education, library and computing organizations and associations.

The NREN will be critical to increasing the nation's research productivity and economic competitiveness through rapid diffusion of research and educational technology that meets national needs. For the past several years, a number of federal agencies, several state and regional network organizations, and many colleges and universities have been working to bring the benefits of high performance computing and advanced networks to their instruction and research programs. Considerable progress has been made, with hundreds of campuses and research sites already connected to existing low to medium speed networks. The initial successes and potential for far greater positive impact on the nation's research capability, as well as improvements in educational productivity, call for the stimulus of federal investment.

To realize these objectives, NREN legislation must incorporate the key points listed on the attachment. In summary, these points are based on a conviction by the members of the NREN Partnership that:

Creation of a federal, state and local networking partnership, with contributions from all levels, will be essential to the success of the network;

Education in its broadest sense complements established research objectives as a reason for development of the NREN;

All involved constituencies of the NREN must have a voice in the development of network policy.

All fifty states should be provided high capacity access to the network.

It is anticipated that the President will include a proposal on the NREN in his FY92 budget; however, there are a number of issues unaddressed by current Administration plans that we believe require legislative action by the Congress. In addition, although Congressional hearings were held last year, and S. 1067 (The High Performance Computing Act of 1990) passed the Senate, the bill did not include many of the provisions we believe are essential to the success of the NREN.

We look forward to congressional hearings in this session on bills incorporating these points and to working with you on this important legislation.

Sincerely,

KENNETH M. KING, *President.*

MEMBERS OF THE PARTNERSHIP FOR THE NATIONAL RESEARCH AND EDUCATION NETWORK

Advanced Network & Services Incorporated
American Association of Law Libraries
American Association of State Colleges & Universities
American Council on Education
American Library Association
Apple Computer Corporation
Association of American Universities
Association of Research Libraries
AT&T
Bell Atlantic
CAUSE
Chief Officers of State Library Agencies
Coalition for Networked Information
Computing Research Association
Corporation for Research and Educational Networking
EDUCOM
The Federation of American Research Networks
IBM/Academic Information Systems
MCI Corporation
National Association of State Universities and Land-Grant Colleges
Special Libraries Association

THE NATIONAL RESEARCH AND EDUCATION NETWORK

A POLICY FRAMEWORK

Purposes of the Network

The purposes of the NREN program should include:

Research and development of advanced communications facilities and techniques for use throughout the U.S. economy;

Development of methods for providing network access to research and educational information resources in electronic form, from both public and private sources;

Use of advanced networks in the national research community, both public and private;

Increases in the rate of technological innovation, including transfers of technology from public and private research programs to all sectors of the economy;

Use of networks, of both current and future technical capability, in federal, state and local educational programs at all levels;

Development of the human resources needed to promote widespread and productive use of the network;

Use of the NREN as a prototype for future advanced communications networks that would serve all citizens through the facilities of commercial service providers.

Access to the Network

Federal, state and local research and education agencies, libraries and educational institutions and organizations should be responsible for ensuring that teachers, students and researchers have access to the NREN to assist in their work.

Libraries, research sites, publishers and other affiliated organizations should be encouraged to connect to the NREN so that their electronic information resources may be made as widely accessible on the network as possible.

Funding of the Network

The federal government should continue and accelerate the level of support it provides for research and development of advanced communications networks which will provide the technical base for the NREN in the future.

The federal government should fund collaborative projects among federal agencies, universities and industry that are designed to encourage rapid transfer of advanced communications and information technology to the private sector.

The federal government in partnership with state and local agencies, libraries, and research and education institutions should provide the resources for network use in research and education programs. Specifically, the federal government should fund, as part of essential infrastructure for research and education programs, interstate access from all 50 states to the NREN. In addition, the federal government should provide matching grants and other appropriate forms of startup assistance to state and local education agencies, libraries and institutions to enable the benefits of the NREN to be brought to faculty and students at all levels at the earliest possible time.

Governance of the Network

The federal government, in partnership with the states and public and private network organizations and user groups should establish an independent, non-government function (which could be a board, an agency, a federally chartered activity) for the NREN whose task is to set and administer policy and to guide planning for the development of the NREN. The members of the board should be selected so as to ensure balanced participation by users (including government, the private sector, education and libraries) of the network in establishing policy.

Responsibilities of the board should include technical standards for the NREN, to be developed and administered by a panel that is broadly representative of academic, industry and government experts in computer and communications technology. The NREN should be required to adhere to national and international networking standards where applicable and consistent with the goals of the network.

To the maximum extent possible, operating facilities needed for the NREN should be procured on a competitive basis from private industry in order to encourage the early development of advanced communications facilities within the private sector.

Senator FORD. Thank you, Dr. King.

Dr. Ricart.

STATEMENT OF DR. GLENN RICART, PRESIDENT, FARNET

Dr. RICART. I am the Director of the Computer Science Center at the University of Maryland, and I am also the principal investigator on the SURANET project.

SURANET connects together 100 institutions of research and education in the Southeast, including Kentucky and Louisiana.

This year, I also serve as the President of FARNET. FARNET is an association of networks such as SURANET that provide for the linkages between the Federal networks and schools such as MIT.

We are the ones who fill that intermediate role between the mission-specific agency networks and the schools and research institutions of this country.

Let me explain why I believe it is so important to build this Federal high-performance computer network. First of all, as a researcher, I need to build on the results of others. I can have more and better results to me over the network than I can find in any one given library, that is important.

Second, I need to have interaction with my peers. Of my 10 closest associates, only two of them may be physically at College Park, the others may be across the country. If I can have interactions with them which are prompt, which are rich in content, I am going to develop better ideas than any one person alone could develop in isolation.

Third, we need to share unique resources. For example, you know that we are building in the Southeast, the continuous electron beam accelerator facility in Hampton Roads. This will deliver a tremendous amount of scientific data, with SURANET enhanced to the multi-gigabit speeds, envisioned by S. 343, that accelerator could be accessed by scientists located at institutions throughout the Southeast and throughout the country.

These first three benefits will give rise to a fourth one: the democratization of science. For example, Prairie View A&M University, a historically black university in rural Texas, is an active user of the Department of Energy laboratory and computer facilities at Fermi Lab.

Fifth, they are going to be positive effects I cannot foresee. In my 20 years of computer networking, I have never been able to overestimate what the future can bring. That applies to research, but I think the same thing applies in education from K through 12, on through life-long learning.

With the vast majority of research, education and technology transfer occurring in U.S. colleges and universities and other institutions of education, the Federal high-performance computer network ought to be heavily influenced by these institutions.

I think that Energy has very specific mission oriented responsibilities that create unique network requirements, but the universities and other research institutions that will be a part of the S. 343 consortia will have contracts and grants with other Federal agencies as well.

It would be wasteful to have separate high performance network connections to each Federal agency. We urge the Department to work with other departments on a single cross-disciplinary, multigigabit national network when dealing with universities and other non-Federal research agencies. The Office of Science and Technology Policy has an important role to play.

We also urge a management structure in which research and education will be represented, not merely a pure Federal effort. As 343 is presently drafted, it leaves too much responsibility to the Secretary of the Department of Energy to interpret all needs and priorities of the existing regional and State networks which are governed by the research and education communities who really appear to be forgotten in this bill. Libraries are not mentioned.

We need a networking structure in the United States that integrates the National Laboratories and the universities, not one that separates them. I mean this in both the connectivity sense and in the management sense.

I must note that we have had great success so far in a decentralized approach to national networking. Local, State and regional networks function together well with a minimum of coordination. That decentralization has allowed the network to take advantage of leveraging local, State and university investments. It is hard to believe that a program of predominantly central management would be as flexible as innovative or as rapidly evolving as today's decentralized structure.

I believe the National Laboratories can develop for us two key technologies for our national multi-gigabit network with connections to and representation from research and education.

First, wide use of the network in education, primarily primary, secondary, and continuing education, will require low-cost computer access stations. Right now we do not have this. We have to go buy a separate computer, a separate modem, a separate data service unit, and so forth. The National Laboratories could develop integrated low-cost network access stations. It would help the network a great deal.

Second, we need a massive conversion of the print material that we currently have so they can be transmitted across the network and used effectively in research. The National Laboratories could take a role on developing laser digitizers that convert these materials to the digital form which is the medium of the future. It will take something like the National Laboratories with their capabilities and their foresight to be able to develop that technology in advance of its commercial feasibility.

If I sound optimistic, Mr. Chairman, it is because I am. The usage on the computer networks has grown at 15 percent per month compounded for 4 consecutive years. That means a factor of five increase every year. About half of that growth rate is from new users and about half is from new users, and about half is from additional use by those already connected.

The Federal high performance computer network envisioned by 343 will be an stimulating and exciting catalyst to U.S. research, education, and sponsored technology transfer to industry. The benefits will flow not so much to individual researchers as to the United States and its ability to innovate and compete in the world.

In summary, it is my opinion that a Federal multiagency, decentralized and gigabit network with connections to and, importantly, representation from research and education communities will provide a powerful strategic advantage to the United States. The National Laboratories have a very important role in this formula. I urge that S. 343 incorporate language that supports this vision.

Thank you.

[The prepared statement of Dr. Ricart follows:]

Prepared Statement of Dr. Glenn Ricart, President, FARNET

INTRODUCTION

It is a distinct pleasure to be here today to testify with respect to the high performance computer network envisioned by S. 343. I am the Director of the Computer Science Center at the University of Maryland and Principal Investigator on the SURAnet Project which links approximately 100 research and education institutions. SURAnet is sponsored by the Southeastern Universities Research Association with 40 members in the southeastern United States.

This year, I am president of FARNET—a federation of more than 30 American computer networks serving research and education.

EXTENSION TO RESEARCH AND EDUCATION

The United States spends more money on research and development than any country in the world. But on a per capita basis, we rank behind several of our competitors. We must make efficient use of our research dollars. The proposed Federal High-Performance Computer Network can help provide that efficiency in several ways if it is extended to serve research and education.

At present, the network established in Section 6(a) appears to be created basically for Federal agencies and departments (Section 6(a)(2)). This is far too limited. The network should be extended to other research organizations including research universities and cooperative organizations such as SURA and to education generally in the United States. This extension would allow the network to serve the education and research activities of Section 6(b) and the consortia of Section 6(c).

Let me explain why it is so important to build the research and education communities into S. 343.

First, research is a process of reaching ever higher by standing on the shoulders of others. A properly constructed network will give me access to both more varied and more timely research results than I can now find.

Second, research is a process aided by interaction with my peers. Of my ten closest peers, only two are physically located locally to me. Today's computer networks provide mechanisms that keep me in touch with them. When the back-and-forth is prompt and rich in content, it allows ideas to be developed that are richer and more profound than any single person could derive.

Third, we need to share our unique research resources. For example, the Continuous Electron Beam Accelerator Facility (CEBAF) now being constructed by SURA under contract to the Department of Energy near Hampton Roads, Virginia, will deliver a tremendous amount of scientific data. With SURAnet enhanced to the multi-gigabit speeds envisioned by S. 343, this accelerator could be accessed by scientists located at institutions located in the Southeast and across the country.

The first three benefits will give rise to a fourth: the democratization of science. For example, Prairie View A&M University, an historically black university in rural Texas is an active user of Department of Energy laboratory and computer facilities at FermiLab.

Fifth, there will be positive effects I can't foresee. In my 20 years of computer networking, I've never been able to overestimate what the future can bring.

So far I have been speaking of research, but all of these things are of tremendous benefit to education as well—from kindergarten through higher education and on into lifelong continuing education.

MANAGEMENT STRUCTURE

With the vast majority of research, education, and technology transfer occurring in U.S. colleges, universities, and other institutions of education, the Federal High-Performance Computer Network should be highly influenced by these institutions. While I believe that Energy has specific mission-oriented responsibilities that may create unique network requirements, the universities and other research institutions that will be a part of the S. 343 consortia will have contracts and grants with other federal agencies as well. It would be wasteful to have separate high performance network connections to each federal agency. We urge the Department to work with other Federal Departments on a single cross-disciplinary multi-gigabit national network when dealing with universities and other non-Federal research agencies. We hope that the Office of Science and Technology Policy plays a strong role in the network.

We also urge a management structure in which research and education are represented. S. 343 as presently drafted leaves too much responsibility to the Secretary of Energy to interpret all needs and priorities. The existing regional and state networks which are governed by the research and education communities appear to have been forgotten in S. 343. Libraries are not mentioned. We need a networking structure for the United States that integrates the national laboratories and universities; not one that separates them. I mean this in both the connectivity and management senses.

I must note that we have had great success with a decentralized approach to national networking. Local, state, and regional networks function well together with a minimum of coordination. The decentralization has allowed the network to take advantage of leveraging university, local, and state investments. It is hard to believe that a program with predominantly central management would be as flexible, as innovative, or as rapidly evolving as today's decentralized structure.

NATIONAL LABORATORIES

I believe the national laboratories can develop two key technologies for a national multigigabit network with connections to and representation from research and education.

First, wide use of the network in education, particularly primary, secondary, and continuing education, will require low cost network access stations. At present, we must buy several different components from different companies and make them work with each other. The national labs could develop an integrated low cost network access station.

Second, we need a massive conversion of existing print and slide materials to electronic format so that they can be transmitted over the network and used effectively in research. The national laboratories could develop laser digitizers that convert these materials to the digital form that will be the medium of the future.

POTENTIAL

If I sound optimistic, it is because I am. The usage on the computer networks we now have has grown by an average of 15% per month, compounded, over the last four years. This represents an increase by a factor of 5 every year. About half of that growth rate is new users. The other half represents increasing use by those already connected.

The Federal High-Performance Computer Network will be a stimulating and exciting catalyst to U.S. research, education, and technology transfer to industry. The benefits will flow not so much to individual researchers and students as to the United States and its ability to innovate and compete.

SUMMARY

It is my opinion that a federal multi-agency and decentralized multi-gigabit network with connections to and representation from research and education communities will provide a powerful strategic advantage to the United States. The national laboratories have an important role in this formula. I urge S. 343 incorporate language that supports this vision.

Senator **Ford**. Thank you, Dr. Ricart.

Mr. Thorndyke.

STATEMENT OF LLOYD M. THORNDYKE, CHIEF EXECUTIVE OFFICER, DATAMAX, INC.

Mr. **Thorndyke**. Thank you, Senator Ford and the committee, for the opportunity to discuss the thoughts for the establishment of the high performance computing network and program. I come here as an individual and a member of the Institute of Electrical and Electronic Engineers Computer Society, Scientific Supercomputer Subcommittee. However, this testimony does not represent IEEE's policy position.

My 35-year business career has been spent in the high performance computing or supercomputing side of the industry, so you know from where I am coming. Until recently, I was a senior executive with Control Data Corporation, a lifelong builder of supercomputers, and I was founder, president and CEO of ETA Systems, Control Data's supercomputer subsidiary.

In choosing a method of implementation of the HPC, Congress should explicitly recognize there are two types of agencies under consideration. The first, represented by DARPA and NSF, are agencies that administer programs and manage funds but do not themselves carry out the research and development.

The second type of agency represented by the Department of Energy and NASA administer and manage programs as well as perform research and development in support of their missions. This fundamental distinction should be kept firmly in mind when responsibility for implementing the HPC networks are assigned.

Since the early 1950's, the AEC and now the DOE have been premier users and a driving force in the development of high performance computer systems now known as supercomputers. The DOE acquisition of supercomputers and articulation of future requirements gave U.S. industry access to highly confident customers and encouraged development. Although the designs of these supercomputers were optimized for the needs of the DOE laboratories, the supercomputers serve equally well for a wide variety of industrial, scientific, and engineering needs.

The DOE labs, exemplified by Los Alamos National Laboratory and Livermore National Laboratory, have historically played a pivotal and often critical role in the development of high performance computing and communications. Scientists at Los Alamos collaborated with the staff of Cray to develop software which is so essential for the total systems operation. Similar collaboration occurred between Livermore Laboratories and Control Data leading to Control Data's best selling supercomputer, the Cyber–205, which was a forerunner for the ETA–10.

Livermore National Laboratories played a critical role in the development of high performance storing devices which are essential to supercomputer operation. Dr. Sidney Fernbach, then director of computation at Livermore, worked with me and my team at Control Data in the development of a high performance disk subsystem, the CDC-819. This was to remain the standard supercomputer disk storage device for nearly 15 years. The scientists and engineers at Livermore Laboratory's experience and understanding of their own application was essential to successful introduction of this disk system to the marketplace.

More recently, in the last half dozen years Los Alamos and Livermore have been active in improving the state-of-the-art of high performance communications. The high performance parallel interface channel, or HIPPI channel, was a cooperative effort by the staffs of Los Alamos, IBM, and others to satisfy a need for a high speed channel interface.

These four cases—the Cray-1, the Cyber-205, the 819, and the HIPPI channel—are only a few examples of the ability of the National Laboratories to work with industry at the state-of-the-art to develop practical new technology and products. Industry then takes these products to the marketplace. The laboratories accomplished these feats while pursuing their mission requirements.

The role and success of the two types of Federal agencies must be a significant factor in the consideration for assignment of responsibility for the HPC network effort. The track record of the Federal agency involved is an important consideration in attaining the goals of Federal involvement which will decrease in time.

The record shows that mission-oriented entities such as Los Alamos and Livermore Labs are focused on performing their mission. They develop, acquire, or cause to be developed tools to enable them to perform their missions. It is precisely this focus on missions that result in effective capability to the user community. They accomplish this by evolving industry so that they can take the technology and create new products in the marketplace.

Historically, the most advanced supercomputers have been placed where the greatest technical staff exists to smooth their introduction into use. The DOE labs are among the first users of each new generation of supercomputers. These computers must be networked at speeds beyond those required by today's current supercomputers. The DOE labs should be assigned the lead responsibility and given the funding development for the HPC network, allowing remote access to these new supercomputers.

The added requirement to move the responsibility of this network from Federal control into the private sector would result in this becoming part of their mission. However, placing the leadership responsibility for the highest performance element of the network outside of DOE is, in my judgment, wrong.

The only question is, once a program is launched, what leadership arrangements are best to achieve the goals. The IEEE Computer Society's Scientific Computing Subcommittee members strongly believe that the DOE National Laboratories are best equipped with staff, experience, leadership, and a strong track record to attain the HPC goals. There are, of course, implicit budgetary burdens which must be addressed regardless of which organization is to take on these responsibilities. These budgetary concerns must not be overlooked or the HPC program will get off to a slow start, and that is not in the best interest of our Nation.

Thank you.

[The prepared statement of Mr. Thorndyke follows:]

PREPARED STATEMENT OF LLOYD M. THORNDYKE, CHIEF EXECUTIVE OFFICER, DATAMAX, INC.

DISCLAIMER

This testimony is presented by an individual who is a member of the Institute of Electrical and Electronic Engineers' Computer Society Scientific Supercomputer Subcommittee. Although other members of the Subcommittee support the views presented here, this testimony does not represent an officiel position of the Subcommittee nor an IEEE policy position.

INTRODUCTION

Senator Johnston and Committee members: I want to thank you for the opportunity to testify before you today to express my thoughts concerning the establishment and management of a High Performance Computing Networking Program, or simply HPC. I come here as an individual who is a member of the Institute of Electrical and Electronic Engineers' Computer Society Scientific Supercomputing Subcommittee. However, this testimony does not represent an IEEE policy position nor an official position of the Subcommittee. My 35-year business career has been spent working in high performance supercomputers on the industry side, so you know where I am coming from. Until recently, I was a senior executive with Control Data Corporation, a long-time builder of supercomputers and I was a founder, President and CEO of CDC's ETA Systems supercomputer subsidiary.

TWO TYPES OF FEDERAL AGENCIES

In choosing a method of implementation for the HPC, the Congress should explicitly recognize that there are two types of agencies under consideration. The first, represented by DARPA and NSF, are agencies which administer programs and manage funds, but do not themselves carry out research and development. Some of the staff members at these Agencies come from academic research laboratories, spend a few years on "rotation" and return to scientific and engineering research after their tour.

The second type of agency, represented by the Department of Energy and NASA, administer and manage programs as well as perform research and development in support of their missions. This fundamental distinction should be kept firmly in mind when responsibilities for implementing the HPC Network are assigned. Although both types of agencies have experience with administering funds allocated to universities and contractors, only the second type of agency has an active "inhouse" research staff.

HISTORICAL ROLE OF THE DOE IN-HOUSE STAFF

Since the early 1950's, the Atomic Energy Commission and now the Department of Energy, or DOE have been premier users and a driving force in the development of high performance computer systems. Over the years, the acquisitions of supercomputers by the Department of Energy laboratories and the articulation of their needs for future higher performance computers in an open and ongoing dialogue with the designers and manufacturers of these systems gave the U.S. industry access to highly competent customers and encouraged the industry to develop. Although the designs of these supercomputers were optimized for the needs of the DOE laboratories, to a high degree, these supercomputers served equally well for a very wide range of industrial, scientific and engineering needs. It is, however, the focus provided by a single set of applications which are well understood by a cadre of experts willing and able to communicate their needs to the manufacturers and designers that has made this supercomputer growth possible.

The DOE laboratories, exemplified by the Los Alamos National Laboratory and the Lawrence Livermore National Laboratory, have historically played a pivotal and often crucial role in the development of high performance computing and communications. The Cray 1, the world's first production vector supercomputer, was delivered to Los Alamos in April 1976. At the time, virtually no software had been developed for it. However, the capabilities of the new supercomputer were so great that the laboratory was able to make significant advances in its own mission. In the process, the scientists and engineers at Los Alamos collaborated with the staff at Cray Research to develop the software which is so necessary for total systems operation. Similar collaboration occurred between the Livermore Laboratory and Control Data (CDC), leading eventually to CDC's best selling supercomputer, the Cyber 205, the forerunner to the ETA-10.

The Livermore National Laboratory played a critical role in the development of high performance storage devices which are essential to supercomputer operation. For example, the late Dr. Sidney Fernbach, then Director of Computation at Livermore, worked with me and my team at CDC in the development of a new high performance disk system for supercomputers. This disk system, the CDC 819, was to remain the standard supercomputer disk storage device for almost 15 years. It was used not only on the CDC products, but also by Cray Research on the Cray 1 and successor models. The scientists and engineers at the Livermore Laboratory, cooperating with CDC, caused it to be developed. They were familiar with their own applications and recognized the critical need for this new device.

More recently, in the last half dozen years, both Los Alamos and Livermore have been active in improving the state-of-the-art in high performance communications. The High Performance Parallel Interface [HiPPI] channel was a cooperative effort by staffs of Los Alamos, IBM and others to satisfy a need for a standard high speed channel interface. This interface is now an industry standard with many manufacturers, including Cray, endorsing it.

These four cases, the Cray 1, the Cyber 205, the CDC 819, and the HiPPI channel are only a few examples of the ability of the National Laboratories to work with industry at the state-of-the-art to develop practical new technologies and products. Industry then takes these products to the marketplace. The Laboratories accomplish these feats while in pursuit of their mission requirements.

ROLES OF DARPA AND NSF

The fundamental importance of Federal funding of research in high performance computing and communications through DARPA and NSF cannot be overemphasized. The strength of America's universities and the dynamic character of its industry in high performance computing and communications have been dramatically influenced by programs administered by DARPA and NSF over the last twenty years. They each have worked effectively to build a firm infrastructure of intellectually vigorous organizations that are ready to play an appropriate role in the evolving aspects encompassed by the high performance computing and communications activities.

ARPAnet and NSFnet were pioneering and successful efforts in communication networks. DARPA and NSF played key roles in establishing these research user networks and deserve a lot of credit for the major contributions to the communications network technologies. However, these networks were not designed to provide the performance or operational services demanded by production supercomputer users.

ASSIGNMENT OF LEADERSHIP IN THE HPC NETWORK

The roles and successes of the two types of Federal agencies must be a significant factor in the considerations for assignment of leadership in the HPC network effort. There is no question that the HPC networking program must rely on a strong symbiotic relationship among the activities of all agencies. The currently developed program has demonstrated that this concept is well supported by the agencies themselves. If the goal of the HPC networking program is to put into place a vigorous development effort initiated with Federal funds and structured so that the Federal involvement can decrease in timer then it is important to consider the inherent underlying factors which transcend personalities and effect attainment of the goals.

It is a fact that administrative activities tend to retain administrative control. The record shows that mission oriented entities such as the Los Alamos and Livermore Labs are focused on performing their mission. They develop, acquire, or cause to be developed tools to enable them to perform their missions. They accomplish this by involving industry so industry can take the technology and create products for the marketplace. The Labs are assisted in maintaining this focus by the administrative oversight of the DOE headquarters. It is precisely this focus on mission which results in an effective capability to serve the user community.

It is both historically true and logically consistent that the Labs be assigned the lead responsibility and given the required funding for developing the initial phases of the HPC network. The added requirement to move the responsibility for this network from Federal control would result in this becoming part of their mission. The oversight functions of DOE headquarters and FCCSET would monitor the project to ensure that this transition is faithfully maintained. However, placing leadership responsibility faithfully maintained. However, placing leadership responsibility in NSF, solely a funding agency, is in my judgment wrong and would reduce the chances of an expeditious transition from Federal sponsorship.

We emphasize that there is no disagreement that we are aware of that Federal involvement in the initial phases of this networking is essential. The only issue would appear to concern the best way to ensure that the Federal involvement does not extend any longer than necessary. Also, there is no issue concerning the competence of the National Labs technical staff nor of the competence of the universities and contractors which NSF would choose to perform the initial work were they to have lead responsibility.

The only question is: Once the program is launched, what leadership arrangements will best achieve the goals? Many members of the IEEE Computer Society's Scientific Supercomputing Subcommittee strongly believe that despite the reserved position of DOE which is both politic and conservative (no agency wishes to risk an extension to its mission—especially in these times of tight budgets—without an accompanying budget increase), the DOE National Laboratories are best equipped with staff, experience, leadership and a strong track record to attain the HPC networking goals. There are, of course, implicit budgetary burdens, which must be addressed regardless of which organization is to take on these new responsibilities. These budgetary concerns must not be overlooked or the HPC could get off to a slow start that is not in the best interests of the nation.

Thank you for this opportunity to address you today. I would be happy to answer any questions you may have.

Senator FORD. Thank you very much, Mr. Thorndyke.

I closed my eyes. I am not sleeping. I am trying to think.

We are talking about the Federal Government managing the network. That is what we are getting into here. Is the Federal Government the biggest user of the network? Can anybody tell me whether it is; yes or no?

Dr. RICART. The biggest user of the network is research and education in the United States.

Senator FORD. That would be universities?

Dr. RICART. Universities. It includes the National Laboratories. I will take a guess, and maybe my panelists would like to contradict me. I would say that probably 75 percent would come out of universities.

Senator FORD. Seventy-five percent use the network?

Dr. RICART. Yes.

Dr. KING. I would guess it would be higher than that, and I would say that for every Federal dollar invested in the development of the network, to date there has been $10 invested by colleges, universities, industries, and States.

Senator FORD. Has that been put together in a leadership manner, or are they kind of nickel and diming it together, even though it is $10?

Dr. KING. Their participation has been a consequence of their excitement about the potential of this network and the fact that this network has become absolutely essential in carrying out research in higher education.

Senator FORD. Well, let me ask any of you, then. The administration has used what they refer to now as the Federal Network Council, and they are proposing to form the National Network Council. They propose to create that. I am getting a strong signal that when or if they form that National Council they are not bringing in everybody who ought to be a piece of it, particularly the universities. Do I get the right feeling?

Dr. King. They have not clearly articulated what they mean by the National Network Council.

Senator Ford. Then tell me what you think they ought to have.

Dr. King. I support the notion that the management structure has to be distributed because there are many, many pieces of the network, including pieces run by the Department of Energy and other Energy missions that are dedicated to their purposes and other pieces of the network that have been developed by the university community.

So you need a distributed management structure, but you need a structure in which all of the sectors that are contributing to the development of this network can participate in developing policy. I think that is something that has not yet been defined.

Mr. Thorndyke. Senator, may I answer your first question with a slightly different view?

Senator Ford. Yes.

Mr. Thorndyke. Certainly when you ask who the great majority of users are now, the answer is correct. However, as the first supercomputers were introduced, there were virtually no users until the very selected piece of researchers found out how to make them practical in use.

The great danger is when we go for the masses we will ignore the fact that we must stretch out and develop the networks around these very advanced computers so that the other people can use them.

When I operated a data center with a supercomputer more than 10 years ago there were very few users because, in fact, we did not have the user development. Later on it became a standard device that a lot of people used. So there is, in fact, another view that says that we have to get very advanced networks and introduce these new machines to a select few people, and later on it becomes a standard well-used device.

Senator Ford. You are the former head of Control Data supercomputer subsidiary—is that correct?

Mr. Thorndyke. Yes.

Senator Ford. Perhaps you could shed some light on what the Federal Government could have done to help Control Data. Specifically, what role do you see that DOE can or should play in enhancing U.S. competitiveness in supercomputing?

Mr. Thorndyke. I believe that the Federal Laboratories, by buying the early machines and helping the introduction of these machines into the network and helping in the early software development is essential to any new supercomputer introduction. Unless we in industry in the supercomputer business can get that cooperative help from the very experienced laboratories with the staff to support it, then I do not believe that anyone who can introduce a supercomputer into the marketplace today and make it a practical entity.

Senator Ford. I thank you all. I am going to turn it over now to Senator Bingaman. He will be the Chairman for the rest of the time and close the meeting out. We are all doing little pieces of other things, so I am going to do my other piece right now.

Thank you gentlemen for your testimony. It has been good to see some of you for the second or third time, others for the first time, and I look forward to working with you in the future.

Senator Bingaman.

Senator **Bingaman** [presiding]. Thank you, Mr. Chairman.

Dr. Hecker, let me ask a question about the other part of DOE's budget, the Defense Program part of DOE's budget, the request this year for the weapons technology base in particular. It has been cut, as I understand the figures, from about $429 million in the current year to a proposal for $389 million in fiscal year 1992.

I want any opinion you could give as to the effect that that cut in that part of DOE's budget might have on the ability of DOE to support this high performance computing effort in the respects that I think you alluded to in your statement.

Dr. **Hecker**. It is very significant. In fact, if you translate those dollar numbers to Los Alamos specifically, in the last 5 years we have lost essentially one-third of our nuclear weapons research development and testing funding.

As a result of that, the consequence in high performance computing has been that whereas in the past the nuclear weapons program has essentially allowed us to have the type of interactions that I described and Mr. Thorndyke just described of interfacing with whoever was out there who made the best hardware that we could interface with. So the interactions with Cray and all of the other computing manufacturers were done under the umbrella of the nuclear weapons research development and testing budget.

That is simply no longer possible today because the research base has been squeezed to the point where we simply cannot do that any more. Quite frankly, that is why we have been so aggressive in working with the Department of Energy Office of Energy Research, to say that we feel Los Alamos still has a significant role to play, the way we have played historically, but today we need a broader base to support that, and we also have a much broader range of problems that are quite appropriate for the Office of Energy Research.

So the effect has been significant. That is why we have worked in this direction.

Senator **Bingaman**. I guess the point I am trying to make which I think is consistent with the statement you just made is that while we show an increase in the proposed budget of the administration's requested budget in the Energy Research Office account for this activity, you have other cutbacks in DOE's weapons program budget which more than offsets the kind of increase that we are asking for here.

We have a situation where the Energy Research Office involvement in this is relatively new. I believe this is the first year they have been involved. Maybe I am wrong about that, but I know it is not a longstanding mission of theirs, or at least that is my impression. So I guess I am just trying to explore that issue as to whether DOE's ability to be involved in a leadership role in this high performance computing initiative has in fact been put back because of the budgetary constraints on the weapons side.

Dr. **Hecker**. Your comment is absolutely right on. Let us say any potential increase from this initiative—certainly to date we have not seen any because the initiative has not started—will not offset the decrease in the last few years in the nuclear weapons R&D budget.

But perhaps a more significant item right now is the one of the purchase or at least lend of the next generation of machine. That is what we have been able to do with the nuclear weapons budget in the past.

Today I am facing significant problems. I am not certain how I am going to do that with the next big machine that is going to come around. So this initiative, I hope, will have the financial flexibility that will allow us somehow to pool the resources to buy the next generation of the machine to do what Mr. Thorndyke said we have done so well.

Senator BINGAMAN. Let me also ask you about this diagram that is on page 8 of your testimony, Dr. Hecker. The diagram has in the center of it purporting to pictorially describe the authorized users, and in the center is this HIPPI network which is the high performance parallel interface channel, as I understand.

Dr. HECKER. Right.

Senator BINGAMAN. I do not know. I have not read through all of the different statements here, but I get the distinct impression that this is something which is essentially in place. What we are talking about here with this NREN is essentially the adding to of what you see here as HIPPI. Is that right, or am I mixing a couple things up?

Dr. HECKER. I would consider that to be only one part of it. In fact, it is the part that I described in my statement, the part that we think we can contribute to; that is, the high end part of the network.

For instance, the development of this channel was done at Los Alamos, and it was done because we needed it. We needed to have the Cray be able to talk to a thinking machine, to the output devices, the terminals and so forth. There was nothing available anywhere that was able to do that. So we developed this. That is an 800-megabit capability. So we now have at Los Alamos kind of a mini network that allows these pieces of hardware to talk to each other. So that is the high end.

We actually have a joint project with Cal Tech with the San Diego Supercomputing Center, JPL, and Los Alamos to now take what we have here in a limited scale at Los Alamos and try to do it over 1,000 geographical miles.

What that will do is develop some of what is necessary for the high end of the NREN, but that does not take care of the whole NREN problem because the NSF with the thousands of users who will have different hardware- and software-related problems. So you have to take care of both of them. I think that is what the Department of Energy's concern is. If there is a national network, somebody has to make sure you do the leading edge stuff because that is where they are.

Senator BINGAMAN. Yes, Mr. Thorndyke?

Mr. THORNDYKE. I would like to add to that the fact that the HIPPI channel is here today for today's supercomputers, and we heard Dr. Nelson talk about achieving a terraflop capability, as I recall. That is going to demand a network of significantly more performance than the current HIPPI channel, and we have to start doing the research to bring that channel into being now, not 5 years from now.

Senator BINGAMAN. Let me ask one other question, and then I will defer to Senator Domenici.

Sometimes when I hear the testimony here and some of the statements made about this network that we are contemplating and trying to put in place, I have the fear that, like a lot of things around here, it is being overpromised and we are essentially trying to portray this as something that is going to do everything but your laundry and maybe even that.

Is it reasonable to think that we are going to have a system to do the high end that Los Alamos is moving ahead on and also be something which I think some of the questioning earlier, Senator Gore's comments, talked about, how a school child can go home and plug into this thing and access the Library of Congress? Is there a point where you need to cut this thing off and say we cannot put together one network that is going to do everything that needs to be done in the western world; where we have to identify a reasonably discrete set of objectives, and presumably they relate to supercomputing, and that is what we should concentrate on here, and some of these other things where students want to plug into the Library of Congress should really be done separately?

Dr. RICART. That is a broad range, but it can be done as part of a single technological effort. There will have to be thrusts at the high end. There will also need to be some thrusts for breadth. If we do not have the breadth, we are not going to be sharing the fruits of the supercomputing with the vast majority of science and education in the United States. The nice part is we can deal with this as a single interconnected network. It does not have to be broken up into separate parts.

The appropriate question is, how would you like to establish that balance; what should we go after first?

I agree with the comments that we need to pay attention to the high end, because without the high end there is no ice breaker into the new technology.

At the same time, I think that breaking the ice does not make any sense unless you send some other ships after the ice breaker in order to carry through the goods that are going to reach the majority of scientists and researchers in the United States.

Dr. KING. The technology that is going to reach into homes and allow students to connect to the Library of Congress is technology that will have to be deployed by the commercial infrastructure, commercial enterprises as part of a national information infrastructure.

However, the role of the NREN through a broad range of activities is to develop this technology and to prove its utility both at the very high end and at the middle end and at the low end. I think it has done an outstanding job of doing that. You are leveraging the research and education community in education and in industry to develop the technology which will in the future be installed by commercial entities and will be universal and ubiquitous.

Senator BINGAMAN. For that low end, we have the technology. It is a question of just whether or not we want to make the investment to use it, is it not? I mean, you can sign on for Prodigy and buy a modem for your PC at home, and there are various commercially available programs that can be added to the extent there is any market for them out there.

It is not a question that you need Los Alamos to drop what it is doing and start working on that. That is done. It is a question of whether as a country we want to make the investment to build this wide band capability into everybody's house, I guess. Am I wrong about that?

Dr. KING. No. I think that is substantially true. The problem, though, is that these low end uses involve electronic mail and access to a small number of data bases. The higher education community is trying to get electronic content on the network, particularly the library piece of this effort, trying to get electronic content on the network in a major way.

It is that content, I think, that will lead to very, very broad commercial deployment of low end technology because there will be enough interesting things on the network to cause people to decide that it is important to invest in acquiring that technology.

Senator BINGAMAN. Senator Domenici.

Senator DOMENICI. First, for the record and for the witnesses that went before, let me apologize for not getting here earlier. I seem to have two things at one time. Every time I want to be here on something interesting, I have another one. I am trying my best to get out a simple, easy budget this year, and we are not there yet, so I sneaked out and said good luck to them over there. I had my share of fighting and left.

Anyway, I want to thank Senator Johnston and our Ranking Member from Wyoming for putting this bill in, S. 343. I hope that we do not end up in a three-way shooting match and get nothing with the administration on the one hand saying they favor the initiatives both in the collaborative, consortia type R&D at the DOE and then the idea of a high capacity nationwide computer network, the so-called interstate highway system, and with another major committee that Senator Gore chairs wanting to move a bill that is broader and involves, as they see it, other departments or other agencies a little more than S. 343 and then this committee. I hope that does not cause us to get stalemated and not have a major effort in this area.

I believe we should. We could spend some time here this afternoon, but we will not. Dr. Hecker could put some things in the record about how Los Alamos' supercomputer system is being used in a little State like ours for high school youngsters. It is very exciting. They are excited. It is just that they are right there, and with some monitoring and some tutoring you can involve them in almost an ecstatic way in using a supercomputer.

Dr. HECKER. Senator, I do have in my written statement the example of what we call the New Mexico supercomputing challenge of the high school kids and their interaction with us. I have it in my written statement.

Senator DOMENICI. Frankly, you know it really is incredible because nobody expected so many high school teachers and students to be interested, and it turned out to be much, much larger. I think the competition was enormous.

I only cite it because it seems to me we are terribly remiss as a Nation if we do not have somebody out there in a programmatic way seeking that kind of thing out for many, many millions of young people.

I am sorry, Dr. Hecker. I did not read your testimony. But if Dr. Hecker did not indicate, frankly it was Los Alamos National Laboratory on the demand side that drove supercomputing to where it is. We would not have a Cray if Los Alamos had not made it known in the marketplace that to do their job as a nuclear deterrent leader they needed something bigger than what we had. Frankly, Cray will tell you they were the only ones around. They were the demand side of that, and it was being driven to meet their needs.

Now we have this huge capacity around, and the Energy Department owns it all. Clearly what this committee is worried about is that we do not let that go to waste. First, we should use it appropriately, and if we are going to put additional money in for R&D we should not let that department and its laboratories which created this situation take a very important role.

Clearly, when you go from that to where we are now, as I understand it—and I just put this to the four of you—the administration, my staff tells me, does not oppose the creation of the high capacity nationwide network, the so-called interstate highway system concept, and they do not oppose the creation of an R&D collaborative consortium at the DOE labs. They are a little concerned about whether we have made it too tight rather than loose enough.

Might I ask, is it your general impression that if we could do those two things without conscription, the National Laboratories would be involved in the consortium activities on supercomputing R&D and if we would create and authorize this international highway system, if we could do those that we ought to do it?

What do you say on your end? We will start over here with you.

Mr. THORNDYKE. Yes. With the exception that when you talk about a highway we tend to look at our highway needs today. In many cases we have not looked at what is really going to be our highway needs in 5 years from now. For example, there is now being created high capacity commuter lanes. As we do this superhighway, I am over on the side that says let us build a very high capacity commuter lane because it will eventually be used by a lot of people; not many to start, but eventually it will become the model of the new highway.

Dr. RICART. Yes, let us do it in a distributed way. Let us do it with a multiyear commitment. Let us involve research and education.

Dr. KING. I agree with what Glen just said. I think we need the network, especially the developed high-end aspect that I think we could contribute to; but on a national basis I think the network would help. Could one help in terms of collaborative centers or whatever you call them, centers of excellence? Again, I made the pitch that that is the best way the DOE laboratories can serve the Nation's high performance computing initiative.

Senator DOMENICI. Let me just close and thank Senator Bingaman for yielding to me. I have just one further observation.

We draw analogies around, and we think they are pretty good on the surface, like the national interstate highway system as the concept here. But frankly, it falls apart pretty quickly when you get out there in the field. It is very easy to use the interstate highway because it accommodates anybody who has a car and it does not require that you know about it and that you make terribly serious decisions about using it because it is kind of there and everybody will know about it sooner or later.

One of the really big problems with access to this kind of system, at least in my opinion, is the tremendous diversity of need out there and the lack of understanding and knowledge about what is available and the enormous duplication that exists out there in furnishing some kind of service that is similar to or close to.

This would be a public kind of entity, and, frankly, public entities of this type in that kind of an arena do not necessarily work as well as more private ones that are pushing it for their own interest. I do not know how to marry the two up, but I am absolutely convinced if there was some private interest in pushing the access and use of this system along with the Federal Government putting it together, it would really work better.

I do not know how to do that, but I just leave that as my closing remarks. I am absolutely certain of that. We will spend more the other way, the way we are going to go about it, than if we had two entities and one was private or a series of private ones and one Government one. For now, I will leave it at that.

Thank you all very much for your thoughtful testimony.

Senator BINGAMAN. Thank you all very much. I think it has been a good hearing. We appreciate the testimony.

The hearing is concluded.

[Whereupon, at 4:14 p.m., the hearing was adjourned.]

APPENDIXES

APPENDIX I

Responses to Additional Questions

DEPARTMENT OF ENERGY,
CONGRESSIONAL AND INTERGOVERNMENTAL AFFAIRS,
Washington, DC, May 3, 1991.

Hon. J. BENNETT JOHNSTON,
Chairman, Committee on Energy and Natural Resources, U.S. Senate, Washington, DC.

DEAR MR. CHAIRMAN: On April 11, 1991, David B. Nelson, Executive Director, Office of Energy Research, testified before your committee regarding S. 343, Department of Energy High-Performance Computing Act of 1991.

Following the hearing, you submitted two written questions on behalf of yourself and Senator Bingaman to supplement the record. Enclosed is the answer to question 2 (Bingaman). The remaining answer is still in the clearing process and will be forwarded to you as expeditiously as possible.

If we can be of further assistance to you or your staff, please contact our Congressional Hearing Coordinator, Barbara Campbell on (202) 586-8238.

Sincerely,

JACQUELINE KNOX BROWN,
Assistant Secretary.

[Enclosure.]

QUESTION FROM SENATOR BINGAMAN

Question: In your response to a question I asked during the hearing on the subject of funding for DOE's role in the high-performance computing and communications program and the fact that the DOE funding will be through DOE/Energy Research, you made the statement that DOE/Defense Programs funding "will always be there." Would you elaborate on this comment?

Answer: DOE/Defense Programs funding supports the DOE/Defense Program needs which have traditionally included high performance computing. It is my understanding that some of this funding has been used collaboratively in the past on high performance computing projects. DOE Defense Programs has always placed a high priority on high performance computing, therefore, I am expecting that there will continue to be mutually beneficial opportunities for high performance computing collaborations between DOE/Energy Research and DOE/Defense Programs in the future.

DEPARTMENT OF ENERGY,
CONGRESSIONAL AND INTERGOVERNMENTAL AFFAIRS,
Washington, DC, June 3, 1991.

Hon. J. BENNETT JOHNSTON,
Chairman, Committee on Energy and Natural Resources, U.S. Senate, Washington, DC.

DEAR MR. CHAIRMAN: On April 11, 1991, David B. Nelson, Executive Director, Office of Energy Research, testified before your committee regarding S. 343, Department of Energy High-Performance Computing Act of 1991.

At the time of my last letter to you dated May 3, 1991, the response to your question was still outstanding. Enclosed is the response to your question.

If we can be of further assistance to you or your staff, please contact our Congressional Hearing Coordinator, Barbara Campbell, on (202) 586-8238.

Sincerely,

JACQUELINE KNOX BROWN,
Assistant Secretary.

[Enclosure.]

QUESTIONS FROM SENATOR JOHNSTON

Question: In your testimony you stated the Administration's support for section 8(c) allowing the Secretary of Energy to protect commercial information produced under this program which will be needed to prevent the unauthorized or premature disclosure of critical information for U.S. industry participants in the program. Would you also clarify the Administration's position on the following:

> Section 8(a) requiring title to inventions or software created to vest in the U.S. and be governed by the provisions of 42 U.S.C. 5908, except as otherwise provided under the National Competitiveness Transfer Act of 1989 (103 Stat. 1674).
>
> Section 8(b) prohibiting disclosure of trade secrets or commercial or financial information that is privileged or confidential, under the meaning of 5 U.S.C. 552(b)(4), and which is obtained from a non-Federal participant in research activities under the Act?

Please state whether these provisions are needed, and if so, why? If they are needed, does the language adequately address these needs? If so, please explain how the language adequately addresses these needs. If not, please provide language that would.

Answer: Section 8(a) of S. 343 as introduced would provide that title to "software creations" arising from the High Performance Computing Program vest in the United States. Title or other rights to these software creations would then be waivable by the Department of Energy (DOE) in a manner that would protect the Government's or the public's interests.

We understand that the Committee deleted this section from the bill in order to allow further examination and debate prior to enactment. The Administration concurs in this decision.

Section 8(b) of S. 343 as introduced would prohibit the disclosure of trade secrets or commercial or financial information that is privileged or confidential. Given the important role that trade secrets now play in the protection of industrial intellectual property in software, private sector participants in the government's high performance computing and communications program may be reluctant to participate if they are not assured that their privately developed and commercially valuable information cannot be protected from disclosure. Language similar to S. 343 as introduced was incorporated in the National Competitiveness Technology Transfer Act of 1989 to allay the fears of potential participants in cooperative research and development agreements (15 U.S.C. 3710(c)(7)(A)).

Section 8(c) would provide the same protection to commercial information produced under this program, as discussed above for 8(b).

LOS ALAMOS NATIONAL LABORATORY,
Los Alamos, NM, May 1, 1991.

Hon. J. BENNETT JOHNSTON,
Chairman, Committee on Energy and Natural Resources, U.S. Senate, Washington, DC.

DEAR SENATOR JOHNSTON: Thank you for having asked me to be a witness before your Committee to testify on the Department of Energy High-Performance Computing Act of 1991. I enjoyed the hearing and was delighted with the progress you and Senator Gore made at the hearing in reconciling some of the differences between your two bills.

Enclosed is my response for the record to the two written questions you sent to me on April 18, 1991. I look forward to working with you in the future on both computing and other topics.

Sincerely,

S.S. HECKER, *Director.*

[Enclosure.]

RESPONSES TO ADDITIONAL QUESTIONS

Question 1. Is the level of funding that is being proposed for the DOE role in the national high-performance computing and communications program adequate? Are there any potential problem areas because of funding limitations?

Answer. The overall level proposed for the Federal high-performance computing and communications initiative (HPCCI) appears reasonable, especially considering the increases scheduled beyond FY 1992. However, I believe that modest increases to the DOE FY 1992 budget would bring substantial returns on the investment. Initial investments in the centers of excellence will have significant payoff in subsequent years.

I mentioned in my testimony that the leading-edge high-performance environment will require numerous enabling technologies (e.g., high performance computers, massive data storage and retrieval systems, very high-speed networks, distributed environments, efficient computational models and algorithms). Of particular importance are early production models of future high performance computers such as the next-generation Connection Machine, the Intel Touchstone, or the Cray Research MPP. It is absolutely essential to the success of this initiative that the most powerful early production computers be available to the HPCCI in a timely fashion. The success of the second-generation Connection Machines at Los Alamos has brought this fact home over the last two years. The latest experimental production supercomputers must be a cornerstone of HPCC centers of excellence and a driving force for the development of an integrated, problem-solving environment.

Hence, on additional $6 to $8 million would be required (to increase the DOE budget from $28 million up to the range of $34 to $36 million) to adequately fund one or two centers of excellence to support the acquisition of the next-generation early production model machines and to develop the rest of the computing system environment.

In addition, DOE could significantly strengthen the response of the computing industry to DOE's needs by supporting industry R&D to develop computing systems responsive to DOE applications. DARPA has historically played a strong role in this area, and it has been assigned the lead in the Federal HPCCI for this activity. However, the DOE requirements are sufficiently different that the Department could very effectively augment DARPA's role, I recommend that an additional $5 million in FY 1992 devoted to industrial R&D should be considered.

Question 2. In your written and oral statements to the Committee in the hearing on April 11, you emphasize centers of excellence for DOE. Could you be more specific—how many such centers within DOE do you envision (both in the early stages or the program and then in the later years as the program has developed)? Are you considering a center at every DOE national laboratory?

Answer. I prefer that the Department of Energy retain maximum flexibility in determining how many centers should be established and what selection criteria are employed, However, the center of excellence concept inherently implies that there are very few. Not everyone can, or should, be at the leading edge.

Sufficient funding must be invested in these few centers that they can actually define the leading edge and make a difference. Establishing many centers will dilute the resources below critical levels. This is especially important in light of the answer to your first question with regard to the high costs associated with the next generation of prototype machines. With this in mind, I don't see how the funding profile envisioned can support more than two DOE centers now.

In spite of the fact that there should be very few centers of excellence, I believe strongly that the computational capabilities at all DOE laboratories must be upgraded through the HPCCI. The laboratories should contribute to grand challenge problems on the basis of their expertise. The centers should help the other laboratories in high-performance computing, preferably by offering their leading-edge capabilities through networking in the spirit of geographically distributed centers. This, of course, is in addition to sharing the knowledge and experience gained at a center with the other laboratories.

APPENDIX II

Additional Material Submitted for the Record

PREPARED STATEMENT OF THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, UNITED STATES ACTIVITIES

It is a pleasure for the IEEE-USA to be able to submit this statement for the record on S. 343, the Department of Energy High Performance Computing Act of 1991.

The IEEE-USA is the world's largest engineering society representing more than 320,000 worldwide, of whom approximately 250,000 live and work in the U.S. The IEEE seeks to advance the fields of electrical, electronics, and computing engineering by disseminating scientific and technical information on a global basis. Within IEEE, the United States Activities Board addresses policy issues relating to the broad scope of communications services and develops recommendations on those issues.

The IEEE commends the attention now being paid by the Administration and by Congress to the field of high performance computing and communications. There can be no doubt that this technology stands near the top of any list of "critical technologies." The U.S. computer industry has traditionally been a world leader and an increasingly important sector of our economy. Information technology is a foundation technology for efforts to shore up productivity (and, hence, competitiveness) in many industries in both the service and manufacturing sector. More powerful computing systems are also vital to meeting the so-called Grand Challenges: understanding global climate change, mapping the human genome, curing disease, analyzing data from huge experimental instruments (such as the supercollider or earth-orbiting telescope) and understanding the behavior of a wide variety of complex processes from turbulence and combustion to the formation of the universe.

The Department of Energy, through its national labs, has always been a major player in pushing the state of the art of supercomputers—the largest and most powerful of the machines we class as "high-performance." Driven by their own needs for ever greater computing power, labs such as those at Livermore and Los Alamos have not only worked closely with manufacturers to produce next-generation machines, but have also developed great expertise in the even more difficult art of using them effectively to solve problems in engineering and science.

Thus, it is most appropriate that the Department of Energy be a key player in any High Performance Computing Program.

KEY POINTS

The IEEE would like to emphasize a few key points regarding the state of high-performance computing in the U.S. and needs in the field.

> The U.S. high performance computing firms are world leaders, but are increasingly vulnerable to foreign competition. This competition is to be expected, given the inevitable growth of high tech economies world-wide and direct foreign government attention to computing as a critical technology. But, expected or not, it represents a real challenge to a sector that has been a key one to the U.S. economy.
>
> Even if there were no competition from abroad, it would be in the national interest to see high-performance computer technology move ahead as rapidly as possible. It is key to national security, industrial productivity, research and education, and to improving our understanding of critical technical problems such as global warming.
>
> Increasing computing power substantially from what it is today will require a major basic and applied research effort. Traditional computer design strategies are running into basic physical limits so that they will simply not carry the

burden of delivering trillions of computations per second. To do so, computer designers are designing new arrangements for the elements that make up computers. We need to have both better theory and experience of how these new architectures work and can be programmed.

Effective use of these new HPCs will require basic and applied research as well as extensive new software development. Researchers using computers usually expect to migrate relatively smoothly to the next generation machines. While these migrations have not always been painless, each generation of supercomputer resembled the previous to such a degree that the move has been straightforward. The new architectures that are now appearing on the design and research boards will require entirely new concepts to program and use effectively. Developing computational methods and software from operating systems to compilers to final application programs will be a major task.

The computer industry, particularly the high-end firms, have always had and will need to continue a close relationship with government R&D users and computer researchers if it is to continue its technical leadership. At least in part this is due to the fact that the Federal agencies such as the Department of Energy have been "leading-edge" users, with demands for performance that outstripped those coming from the private sector. Although the private sector is now beginning to be a more active market for high performance computing, this dependence will continue.

In the first place, the research necessary to develop, not the next generation machine but the one after that, is becoming more expensive and risky. Yet, U.S. firms at the leading edge tend to be relatively small—far too small to invest substantially in blue sky research without reasonable assurance of appropriate results. Government needs to continue and increase its investment in research at this generic level.

Secondly, users do not normally have the technical expertise to either evaluate radical new designs or transfer their applications to ones that appear promising. Government and government-funded researchers need to continue to push the state of the art in computational science and see that these new techniques are transferred to the broader community.

These points add up to the need for a long-term, well-funded, and tightly coordinated Federal High-Performance Computing program such as the one of which S. 343 would be part.

The bill has three substantive sections, and we would like to comment briefly on each of them.

HIGH PERFORMANCE COMPUTING PLAN

Department of Energy research facilities include some of the largest, and the most data-rich scientific instruments and projects that exist in "Big Science." And future planned instruments such as the supercollider will generate even greater data streams. The Secretary of Energy, in developing the DOE High-Performance Computing Plan, will have an ideal opportunity to assess the overall needs of R&D for access to scientific computing, communications, and storage capacity as well as to develop a reliable inventory of available resources.

The high-performance computing issue was initially raised in the Lax Report in 1984, which argued that an extreme imbalance between research needs for supercomputing and available resources exist. That argument, backed more by-anecdote than hard data, struck policy-makers as convincing (and still does). However, since 1984, although science has grown even more data intensive, we have not developed any better quantitative estimates of need and available resources. Such data will become very important in helping to answer the "how much" questions that become important once the decision is made to do something. (How many supercomputer centers do we need? How wide do the communication paths have to be? How big must the data bases be and how fast must they perform?)

COLLABORATIVE CONSORTIA

With its provision for collaborative consortia, S. 343 seeks to capture the expertise in high-performance computing that resides within the labs, institutionalize it within the labs, and put it to work as part of a cooperative interagency effort. Such consortia would, if organized properly, provide a tight coupling between the basic computer science and engineering research at universities and laboratories, and "Grand-Challenges" applications work at the labs and industry—both users and producers.

To do so successfully, however, it is imperative that both university research laboratories and industrial users and producers be full participants in these consortia to the maximum extent possible. Otherwise, one risks funding simply another inhouse government research activity with minimal intellectual impact on the research community and minimal technology transfer to industry.

It is also important to assure that the research supported by the consortia conform to the goals and strategies of the interagency program. This could be done through mechanisms such as setting up external scientific advisory committees or conducting reviews by FCCSET-sponsored committees.

NATIONAL HIGH SPEED DATA NETWORK

The IEEE believes that a very high speed data communications network is a critical component of any plan to expand the information infrastructure for the scientific and engineering research community. Networking has already become a basic tool for technical communication, and we are only beginning to scratch the surface of its potential. It enhances communication among researchers. It provides new ways for industrial and academic researchers to collaborate, thus enabling technology transfer between laboratory research and industrial innovation. Even small hightech firms can participate in research projects, gain access to specialized computers, software and data, and tap relevant expertise anywhere in the world.

Since rapid technological innovation is a key to competitiveness in our economy, the IEEE encourages rapid expansion of what has come to be known as the NREN, and hopes that disagreements over details of its management and operation will not significantly delay its progress.

We would like to stress a few key points about the network that should be taken into account in framing legislation.

> The network already exists and is evolving quickly. It was put together as an informal cooperative effort among key agencies that already operated research-oriented data networks, including NSF, DARPA, the Department of Energy, and NASA. This "Interim NREN", as it has come to be called, now spans the nation. All basic communication "backbone" links will operate at T3 speeds by the end of this year, far ahead of initial schedules and plans and reflecting the growing demands of the research community.
>
> The Interim NREN is not a single network, but a network of networks. NREN, in its broadest form, consists of Federal agency networks, private systems, state and regional networks, and, of course, local networks on most campuses and research laboratories. This pattern will undoubtedly continue, with the NREN growing ever more complex. Thus, the network is not a single entity that any one organization will "procure", "build", or "manage" in the traditional sense of the words. Rather, creating NREN will be an act of leadership with a group of partners: Federal and local governments; private and public systems; commercial and non-commercial institutions; users and providers. This is a delicate balance that, for the moment, appears to be working.
>
> The structure and form of this partnership will need to change over time, evolving as the network grows and as the constituencies it serves grow.
>
> In particular, security, privacy and other policy issues are important considerations in designing this network. These are best handled in the early design stages so as not to needlessly disrupt the balances and agreements that underlie the current growth and operation of the NREN.
>
> The IEEE believes that it is in our vital national interest that we move as quickly as possible toward implementing a universal, broad-band communication system in the United States for general commercial use. In addition to serving the technical community, NREN should be seen, in part, as an important leading edge for that development. It will be a test-bed for development and study of basic technologies, standards, high level applications and policies.
>
> To accomplish this objective, it is important to involve, to the maximum extent possible, the private sector-users, information service providers, telecommunications service providers, and so on. They should participate by offering network services and by serving on outside oversight or advisory councils and panels that may be formed to guide NREN development. In this way, technology and experience can be transferred rapidly to industry, NREN services can be commercialized as soon as possible, and the NREN can evolve in a way that support this broader social goal.
>
> To the extent that the network will evolve to serve a wider constituency-education, libraries, and so on—these users will also need to be consulted fully and continually on system design and policy issues. In this way, the NREN can

serve as a continuing test-bed for the broader community of users and not become captive of any single entity representing some narrow group of users.

CONCLUSION

In conclusion, the IEEE applauds the efforts of the Congress and the Administration in moving forward with this important initiative. That this is happening in times of such tight budgets is testament to the belief in the importance of these technologies to our future strength as a nation, a belief that the IEEE holds strongly. In particular IEEE expects such an initiative would create wealth far in excess of its cost. We encourage rapid, although careful and constructive consideration of this and related legislation. We look forward to working with the Congress in developing sound and effective legislation and helping encourage its passage.

Prepared Statement of George R. Sell, Professor of Mathematics and Director, Army High Performance Computer Research Center, University of Minnesota

Mr. Chairman and Members of the Committee: I am pleased to be here today to discuss S. 343 entitled, "Department of Energy High Performance Computing Act of 1991."

This legislation is supportive of the implementation of the High Performance Computing and Communication program that has been thoughtfully designed by a task force of the Federal Coordinating Committee on Science and Technology. This is precisely the program that, under the auspices of the U.S. Army, the University of Minnesota has been implementing. We believe that this is a most successful program, with great benefit for the economic and scientific life of the nation and it should be expanded.

In 1989, the University of Minnesota responded to the Request for Proposals issued by the Department of the Army for establishment of the Army High Performance Computing Research Center (AHPCRC). Our proposal was selected through a major competition for the award of a five year contract, managed by the Army Research Office in Research Triangle Park, North Carolina. The contract awarded to the University of Minnesota includes several key ingredients:

(1) Collaboration with researchers in high performance computing at Howard University, Jackson State University, and Purdue University;

(2) A major cost sharing plan by the University of Minnesota to develop human resources, especially at the graduate and postdoctoral level, and to enhance faculty positions in disciplines strongly involved in high performance computation;

(3) A commitment by the University of Minnesota to use the resources of the contract, together with the computing facilities already at the Minnesota Supercomputing Center (including the largest Cray2 available), to develop algorithms and techniques for massively parallel computers;

(4) Office space at the new building named the Minnesota Tech Center, including adequate space for approximately 28 High Performance Computing Graduate Fellows, 10 Postdoctoral Fellows, 8 Visiting Scientists, support staff, and a modern Graphics and Visualization Laboratory, with fiber optic connections to the Minnesota Supercomputer Center across the street.

RELATION OF THE AHPCRC MISSION TO THE HPCC INITIATIVE

The High Performance Computing and Communication (HPCC) Initiative put forward by the Office of Science and Technology Policy describes four major areas of concentration. I would like to describe how the AHPCRC meets the goals of these four areas and how we intend to further the HPCC program by ensuring that the research and development carried out by the university is directly beneficial to the Department of Defense—in particular, the U.S. Army sites involved in utilizing high performance computing in carrying out their mission.

HIGH PERFORMANCE COMPUTING SYSTEMS

One of the objectives of the AHPCRC is the Evaluation of Early Systems. Our first acquisition was the 32K processor Connection Machine 2, plus high speed channels (HiPPI) for interfacing the CM2 with the Cray 2. Both machines have 4 billion bytes of memory. This will be an interesting test bed for large scale computations that use both the shared-memory functions of the 4 processor Cray 2 and the data parallel features of the CM2. Because the three Army supercomputer centers have

Cray computers, this provides an ideal environment for the development of massively parallel algorithms for future computations.

ADVANCED SOFTWARE TECHNOLOGY AND ALGORITHMS

Software support for grand challenges is a major part of the AHPCRC mission. Through subcontracts with the Minnesota Supercomputer Center (MSC) we have added about thirty competent infrastructure personnel to help train new users of the high performance machines, to develop applications of interest to army scientists in their labs, and to help in interfacing with university researchers to work in areas relevant to army needs. Of these, about half have Ph.D.'s in scientific disciplines, and the rest are competent in programming, graphics, databases, or communications. One-third reside at the MSC to assist local and remote users of the facilities there and the other two-thirds reside at the Army labs.

The AHPCRC supports multidisciplinary teams of faculty, postdoctoral fellows, HPC graduate fellows, research assistants, in practically all departments in the scientific disciplines, not only in the Institute of Technology, but also in the School of Public Health at the University of Minnesota. These teams are involved in the development of Software Components and Tools for high performance computing. They are also concerned with the development and transfer of Computational Techniques relevant to their disciplines.

Of course, the major component of the AHPCRC is that it represents one of the first High-Performance Computing Research Centers called for in the initiative. We have introduced an innovative computational testbed, and we are the focus of several Technology Transfer projects designed to move university research directly into Army labs and research centers.

NATIONAL RESEARCH AND EDUCATION NETWORK

The AHPCRC serves as a major gateway between the NREN and the Army Supercomputer Network (ASNET). Through the combination of all the networks making up the Internet (NSFNet, ESNet, ASNet, MILNet, etc.) the high performance computing facilities at the AHPCRC are directly accessible throughout the United States (and some other countries). Interest in developing one of the "gigabit testbeds" involving Army sites is keen, and projects are in the development stage for testing very high speed remote access to the combined Cray 2–HiPPI–CM2 facility soon to be functional at the AHPCRC. NREN connections provide daily access to our partner universities at Howard University, Jackson State University, and Purdue University, helping to make "remote" partners an integral part of the Center.

BASIC RESEARCH AND HUMAN RESOURCES

The University of Minnesota has decided to direct the major portion of the AHPCRC research dollars towards the development of human resources, especially at the graduate student and postdoctoral level. To meet this goal the AHPCRC has provided an environment for training students in the various disciplines that involve high performance computing. The contract provides for support of a number of HPC graduate fellowships, which must be U.S. citizens. With university cost-sharing, this number is about 20 this year. It also provides for the support (again, with university cost-sharing) of about 10 postdoctoral fellows, and about a dozen short term and long term visitors. Each of the workspaces in the new building is equipped with a modern, powerful workstation (about half of which have color graphics) connected through local networks to the Internet. This environment is ideal for training multidisciplinary students all concerned with the problems faced in computational science. We have students, postdoctoral fellows, and senior visitors in mathematics, computer science, chemical engineering, material science, chemistry, mechanical engineering, aerospace engineering, physiology, pharmacology, . . . all working side by side learning the skills required to do Grand Challenge computational science.

We have begun to develop summer programs involving undergraduate students from our minority school partners. In addition we are facilitating summer work programs at some of the Army labs, as well as prolonged visits to the University of

Minnesota. In summary; I believe that the AHPCRC programs address the strategies described in the HPCC Initiative and we are well on the way to proving the effectiveness of the ideas expressed in that document. The HPCC Initiative, like the AHPCRC programs, 15 addressing a vital national need. It is important that these efforts be expanded. We strongly endorse the objectives of the HPCC Initiative.

This concludes my testimony. I will be happy to answer questions.

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